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American Midland Naturalist

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The Malthini of North America (Coleoptera—Cantharidae)

Kenneth M. Fender

McMinnville, Oregon

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Introduction

The tribe Malthini as recognized in this paper is comprised of those members of the Cantharidae in which the apical segments of the maxillary palpi are ovate and pointed; the elytra more or less abbreviated with the tips of the wings exposed and the male genitalia bilaterally symmetrical, following Champion (1915). Three genera are herein recognized as constituents of this tribe in North America. These are *Malthinus* Latrielle, *Frostia* new genus and *Malthodes* Kiesenwetter.

LeConte (1881), LeConte and Horn (1883) and Leng (1920) included *Trypherus* LeConte and *Belotus* Gorham (*Lobetus* auct. nec Kiesenwetter) in the Malthini. Bradley (1930) accepted and followed LeConte's concept. The genus *Ichthyurus* Westwood, recently recorded for the first time from Arizona, would also have been placed in this group. In these genera, the apical segments of the maxillary palpi are elongate securiform; the elytra abbreviated with the tips of the wings exposed and the male genitalia asymmetrical. They rightfully belong in the tribe Ichthyurini and should be so placed.

The Ichthyurini have apparently been placed near the Malthini on the basis of their abbreviated elytra and small size (2.5 to 5 mm.). The asymmetric male genitalia of the former indicates a much closer relationship with the Chauliognathinae, some species of which have abbreviated elytra, although much larger in size. The Malthini are more closely related to the Podabri and Silini which similarly have the male genitalia bilaterally symmetrical.

The differentiating characters of the species of this group are chiefly the

male terminalia, although coloration differences are occasionally used. The exposed terminal abdominal segments of the males of the Malthini are variously modified. The greatest range of modification is in the genus *Malthodes;* the terminalia varying from a comparatively simple arrangement with the last dorsal segments simple and the seventh ventral elongate, with or without an apical notch; to a complex and intricate pattern that in some species approaches the grotesque. No other North American group of beetles, known to the author, offers such a wealth of interesting features as do these tiny creatures.

A certain amount of caution is required in the determination of specimens of Group I of *Malthodes*. The male seventh ventral, being rather delicate, may be and often is distorted. This condition can generally be recognized as the distortion is usually in an asymmetric manner. To avoid possible incorrect determinations, through the use of the key alone, a careful comparison with the description is advisable.

The females of the Malthini are difficult if not impossible to place unless accompanied by the male. This is particularly true of the genus *Malthodes*. These females have the last ventral abdominal segment narrowly deeply emarginate. The ultimate dorsal is a small narrow median process that is subtriangular in outline with the free angle rounded. There are few females that do not conform to this pattern.

The copulatory position of the majority of the *Malthodes* is end to end. This is especially true of those species in which the terminalia of the males are intricately formed. These segments act as a receptor and clasper for the female abdomen during copulation. Pairs of *M. oregonus, M. humidus, M. frosti* and *M. viscératus* have been taken in coitu. In each event, the forked tip of the seventh ventral of the male was inserted under the apical edge of the fourth ventral of the female. Females have been seen of these and allied species in which the apical margin of the fourth ventral was notably pushed out, the fifth and sixth ventrals being impressed and wrinkled. This indicated that copulation of the kind noted above had taken place and that considerable pressure had been brought to bear. It may be that the male terminalia, in addition to being claspers and receptors, may act as exciters in the completion of the copulatory act.

The need for revisional studies in the Malthini becomes apparent with the realization that more than half of the 122 species, herein recognized, have previously been undescribed, a condition almost unbelievable in an order as presumably well studied as the Coleoptera. Some concept of the desirability of such a study is that the author has seen five different species masquerading under the name *Malthodes exilis,* whereas none of them was the true *exilis*. At the same time, one species has been seen bearing three different names, none of which were correct. Due to errors or too brief descriptions in LeConte's (1881) study, the author has misnamed some species. These misconceptions have finally been corrected with the help of Mr. Floyd Werner of the Museum of Comparative Zoology, who carefully studied and sketched

the male terminalia of the LeConte and Melsheimer types. Without Mr. Werner's efforts, this paper would have been much less accurate than it now is.

History

The genus *Malthinus* was erected by Latrielle in 1806; Gyllenhall having recognized the members as an individual group but placing them as a subdivision of *Cantharis*. LeConte (1851) described the genus *Trypherus* and eight North American species of *Malthinus*. Kiesenwetter (1852) divided the genus of Latrielle, erecting the genera *Lobetus, Lygerus* and *Malthodes*. These genera were differentiated on the basis of palpal and mandibular characters. LeConte's *Trypherus* had precedence over *Lygerus*, making that name a synonym. *Malthodes* was separated from *Malthinus* on the mandibles; simple in *Malthodes*, inwardly dentate in *Malthinus*.

LeConte (1881) transferred five of his previously described species to *Malthodes* and placed a sixth as a variety. In this paper, he recognized two species and a form of *Malthinus* and eighteen species of *Malthodes*. Four of his species of *Malthodes* were described from females. Only one of these four, *M. parvulus*, can satisfactorily be recognized, and that only because of its minute size. Included in the Malthini were *Trypherus, Belotus, Malthinus* and *Malthodes*.

Champion (1915) transferred the genera *Trypherus* and *Belotus* to the tribe Ichthyurini on the basis of their elongate securiform apical palpal segments and asymmetric genitalia. The *Malthini* were confined to those genera with the apical segments of the maxillary palpi ovate and pointed and the male genitalia bilaterally symmetrical as previously mentioned. As to whether or not this arrangement was original with Champion, the author has been unable to determine.

Fall (1919), studying the *Malthodes* of California, added fifteen species and a form of this genus to our list. In the interim (1881-1919) single descriptions were added by LeConte, Bergroth, Horn and Schaeffer. Horn's *Malthodes lucanus*, described from Lower California, is excluded from this work as extraterritorial but is included in the index to species for the benefit of possible future cataloguers. Descriptions by the author from 1943 to date, complete the knowledge of this tribe up to the present study.

Collection and Preservation

The Malthini, as a rule, have a preference for shaded situations. They are collected by beating the branches of coniferous and deciduous trees and shrubs and sweeping the grasses and low herbs of moist or boggy areas or near small water courses.

Each species appears to have a somewhat selective instinct for its preferred habitat. A species found on deciduous trees and shrubs is not likely to be taken from coniferous trees and less apt to be found on grasses. The reverse is true for other species. There are exceptions to this rule but it will general-

ly be found to hold. Insufficient study has been made to determine whether any species is confined to any particular species of plant or not.

In Oregon, where personal observations have been made, *Malthodes humidus, M. frosti, M. alexanderi* and *M. diamondensis* are closely associated *with coniferous* trees; *M. flexuosus, M. hatcheana* and *M. dorothae* with deciduous trees or shrubs and *M. piceolus* and *M. basalis* with grasses and herbs. *Malthodes oregonus* is less particular and may be found in nearly equal abundance on coniferous and deciduous trees but seldom on grasses and herbs.

The Malthini, being quite small (1 to 5 mm.), should be mounted on points. Great care should be employed to keep the point well forward on the specimen and removed from the terminal abdominal segments. Whenever possible, it is advisable to mount the specimens while still fresh. The relaxation of dried specimens often permits the soft and pliable wings and elytra to droop over the abdomen, concealing the terminalia and making the determinations very difficult if not impossible.

To relax specimens, the author prefers to place them in a vessel of nearly boiling water for a few minutes. The pliability of the specimens may be determined by testing an antenna or a leg with the point of a pin. If the specimen is ready for setting, the segment will move with almost no pressure. The specimens are then transferred to a blotter and the excess water removed. The specimens are then glued to their individual triangles. It is advisable, at this time, to place each pin inverted with the head stuck in a piece of moulding clay or yucca wood. In this position, the wings and elytra of the insect dry well away from the abdomen, permitting an easy examination of the terminalia both laterally and ventrally.

Great difficulty has been experienced in attempts to study specimens that were mounted with insoluble glue or shellac. In many instances, where such adhesives were used, identifications were very hard if not impossible to make. The use of excessive quantities of any adhesive should be avoided.

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privilege to be permitted to do so. The names will indicate to whom such species are dedicated.

Few collectors have added more to our knowedge of the coleoptera than has Mr. C. A. Frost. Many of his records and specimens have been included in studies of various groups. Many are the beginners that he has helped and encouraged to greater things. It has been his pleasure to do these things without fanfare and with little compensation. It is indeed a privilege to dedicate the genus *Frostia* to Mr. C. A. Frost.

Malthini of North America

The species of this group are of small size (1 to 5 mm.); the mentum small and quadrate; the gular sutures confluent; the apical segments of the maxillary palpi ovate and pointed; the elytra abbreviated leaving the wings partially exposed; the terminal abdominal segments of the males variously modified.

KEY TO GENERA

1. Mandibles dentate on the inner margin (Plate I, fig. 2); head convex in front or becoming very narrowly concave at the extreme anterior margin of the clypeus (Plate I, fig. 1); elytra striate punctate or confusedly rugose punctured ..... *Malthinus*, p. 517

   Mandibles not dentate on the inner margin; clypeus transversely concave beyond the middle (Plate I, fig. 4); elytra confusedly rugose punctured 2

2. Inflexed outer margin of the mandibles with an acute tooth (Plate I, fig. 3); pronotum with wide, moderately deep impressions; lateral spinose processes of the male terminalia prominent, extending nearly to or beyond the tip of the seventh ventral abdominal segment ..... *Frostia*, p. 524

   Mandibles simple or finely serrate on the inner margin (Plate I, figs. 5 & 6); pronotum without or with very feeble impressions; lateral spinose processes of male terminalia, if present, less prominent, much shorter than the seventh ventral abdominal segment ..... *Malthodes*, p. 528

Genus MALTHINUS Latreille

Latreille, Genera Crustaceorum et Insectorum, 1, Paris, 1806.

Head convex in front of the antennae (Plate I, fig. 1), sometimes with a feeble transverse impression near the apex of the clypeus; mandibles dentate within (Plate I, fig. 2); apical segments of the maxillary palpi acuminate ovate; elytra abbreviated, either confusedly punctate in which event the elytra are usually shorter, or striate punctate in which event the elytra are longer.

KEY TO SPECIES

1. Elytra coarsely striate punctate 2
   Elytra more finely, confusedly punctate 4
2. Elytra black with the apical tumidities dark olivaceous ..... *atripennis*
   Elytra testaceous with the suture more or less widely infuscate 3
3. Male seventh ventral entire, ovate ..... *occipitalis*
   Male seventh ventral deeply narrowed incised apically ..... *difficilis*
4. Pronotum finely closely granulate ..... *granicollis*
   Pronotum finely sparsely punctured 5
5. Pronotum piceous with four discal pale spots and the anterior and posterior margins narrowly pale ..... *quadrimaculatus*
   Pronotum pale, sometimes with a narrow median dark stripe 6
6. Head black behind the antennae ..... *subcostatus*

Head except eyes and antennae pale 7
7. Elytral apices pale creamy yellow, body beneath testaceous ..... *tricolor*
Elytral apices dark olivaceous, body beneath piceous 8
8. Male seventh ventral elongate, produced ..... *bicolor*
Male last ventrals short, transverse ..... *huachucae*

MALTHINUS ATRIPENNIS LeConte

Plate I; fig. 7

Malthinus atripennis LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 60.

Ferruginous; head behind the eyes and all but the basal two segments of the antennae piceous; elytra black, occasionally with a purplish tint, the apices olivaceous; tibiae, tarsi and apices of the femora of the middle and hind legs piceous; pubescence cinereous, moderately long and conspicuous. Length 3 to 3.5 mm.

Male: Head wider than the pronotum, finely sparsely punctured anteriorly, becoming closely rather coarsely punctured on the neck; eyes large and prominent; antennae moderately stout, extending to about the middle of the elytra, segments two and three equal, the fourth slightly longer, the intermediate segments about two and a half times as long as wide; pronotum moderately transverse, constricted and narrowed apically, widest medially, arcuately narrowing to the hind angles which are prominent and narrowly reflexed, marginal bead thick on the apical and basal margins, fine on the sides, disc finely sparsely punctured, an obscure median impressed line extends from the base to the apex; elytra coarsely striate punctate, the apices slightly tumid and finely sparsely punctate, the elytra extending to about the apex of the sixth abdominal segment.

Female: Similar to the male; anterior angles of the pronotum less prominent.

Described from Texas, examples of this species have been studied from: Belfrage, San Antonio, Cypress Mills and Dallas, Texas.

MALTHINUS OCCIPITALIS LeConte

Plates I, II; figs. 8, 22, 23

Malthinus occipitalis LeConte, Proc. Acad. Nat. Sci. Phila. (2) 9, 1851, p. 345.
Malthinus occipitalis LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 60.

Testaceous; head behind the eyes fuscous, the eyes black, the antennae beyond the third segment infuscate; pronotum with a wide median brownish vitta extending from the base to the apex, this vitta sometimes feebly indicated; elytra with the tips yellowish, the suture infuscate, this infuscate area sometimes confined to the sutural bead, at others extending nearly to the lateral margin of the elytra; pubescence cinereous, suberect and conspicuous. Length 2.5 to 3.5 mm.

Male: Head wider than the pronotum, finely sparsely punctured, becoming scabrose at the sides and on the neck; eyes large and prominent; antennae slender, extending to the tips of the elytra, segments two and four equal, the third shorter, the intermediate segments about three and a half times as long

as wide; pronotum subquadrate, strongly constricted and narrowed apically, the sides rounded behind the constriction to the hind angles which are prominent, disc sparsely rather coarsely punctured, rather widely deeply channeled from the base to the apex; elytra long, extending to the base of the sixth segment of the abdomen, coarsely striate punctate to the tips which are tumid and finely punctured; male seventh ventral ovate, entire.

Female: Similar to the male: eyes smaller and less prominent; last ventral abdominal segment narrowly deeply emarginate, a small finely clavate process medially in the emargination.

LeConte described this species from Virginia and Georgia. Additional specimens have been seen from: Massachusetts. Pennsylvania. District of Columbia; Washington. Florida; Hardee County, Lafayette County. Maryland; Beltsville. North Carolina; Black Hills. New York; Ithaca and Wake County. Ohio; Scioto County, Athens County, Delaware County and Hocking County. Tennessee; Gatlinburg (Great Smoky Mountain National Park). Texas; Gillespie County, Leon County, Cypress Mills. Virginia; Pennington Gap, Falls Church.

MALTHODES DIFFICILIS LeConte

Plates I, II; figs. 9, 24, 25

Malthinus difficilis LeConte, Proc. Acad. Nat. Sci. Phila. (2) 9, 1851, p. 345. *Malthinus occipitalis* LeConte (Part.), Trans. Am. Ent. Soc. 9, 1881, p. 60.

Testaceous to reddish brown; head behind the eyes and the apical segments of the antennae fuscous to black; pronotum with or without a median longitudinal fuscous stripe; scutellum and the suture of the elytra more or less widely infuscate; pubescence cinereous, suberect and conspicuous. Length 2.5 to 3.5 mm.

Male: Head moderately large, wider than the pronotum, finely sparsely punctured, becoming scabrose on the sides of the neck; eyes large and prominent; antennae slender, extending to the tips of the elytra, segments two and four equal, the third shorter, the intermediate segments about three and a half times as long as wide; pronotum subquadrate, strongly constricted anteriorly, the anterior angles narrowly reflexed, the sides rounded from the constriction to the hind angles which are prominent and widely reflexed, marginal bead moderately thick, disc finely sparsely punctured to moderately coarsely punctured, medially canaliculate from the base to the apex; elytra extending to the base of the sixth abdominal segment, coarsely striate punctate to the tips which are tumid and finely punctured; seventh ventral subovate, slightly produced and notched at the apex.

Female: Similar to the male; eyes smaller and less prominent; anterior angles of the pronotum a little less evidently reflexed.

Collections of this species are available from: Georgia; Athens, Head River. North Carolina; Highlands. Virginia; Pennington Gap, Falls Church.

This species is uncommonly variable in coloration for members of the

Malthini. In his 1851 paper, LeConte described *occipitalis* and *difficilis* using virtually the same description for each. In 1881 he concluded that they were synonymous, that *difficilis* was a pale form of *occipitalis*. It so happens that *difficilis* can not only be paler but can be considerably darker than *occipitalis*. The only satisfactory differentiating character that could be found externally was the shape of the male seventh ventral: ovate in *occipitalis;* apically notched in *difficilis*. Aedeagal studies will readily confirm any specimen that might be in doubt. The conformation of the aedeagus can frequently be determined by a close examination through the semitransparent seventh ventral, otherwise removal of the aedeagus is required, which is a simple task.

Malthinus granicollis new species

Plate II; figs. 10, 11

Head dark orange with a brunneous interocular fascia behind the antennae, antennae piceous with the basal segment paler at the basal half; pronotum brunneous with slightly paler mediolateral areas; elytra and the body beneath piceous; legs testaceous with the apices of all tibiae widely and the middle of the femora infuscate, more widely so on the hind legs; pubescence cinereous, moderately conspicuous. Length 3 mm.

Male: Head rounded, flat just behind the antennae to behind the eyes then curved into the neck which is stout, finely closely punctured in front, sparsely so behind the antennae and to the neck which is finely closely granulate; eyes small and moderately prominent; antennae moderately stout, segments two to four progressively longer, the intermediate segments about three and a half times as long as wide; pronotum strongly transverse, not constricted anteriorly, the anterior angles rounded, the sides feebly sinuate and subparallel to the hind angles which are obtuse, marginal bead thick, disc finely closely granulose; elytra short, about two and a half times the length of the pronotum, finely sparsely confused punctate basally, becoming rugose apically; seventh ventral ovate, the apex deeply notched.

Female: Similar to the male but the pronotal disc less closely granulose.

Holotype, male, Plummers Island, Maryland, August 5, 1914, R. C. Shannon, in the collection of the United States National Museum; *Allotype*, female, Raleigh, North Carolina, July 15, 1940, R. Barnes, in the collection of Ohio University; *Paratypes:* 1, Bladensburg, Maryland, July 11; 1, Wake County, North Carolina, August 4, 1940.

Malthinus quadrimaculatus new species

Plate II; figs. 12, 13

Piceous; head black behind the eyes, pale in front; pronotum with the anterior and posterior margins more or less pale, small pale spots at the anterior angles and on the callosities; elytral tips yellowish; pubescence cinereous, fine and inconspicuous. Length 3.5 to 4 mm.

Male: Head large, wider than the pronotum, finely sparsely punctate in front, becoming closely granulate on the neck; eyes small and prominent;

antennae slender, extending to the tip of the abdomen, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum moderately transverse, the anterior angles rounded and narrowly reflexed, the sides evenly rounded to the obtuse hind angles which are narrowly reflexed, margins rather thickly beaded, disc finely sparsely punctured, a rather low callosity medially on each side, a fine median longitudinal impressed line arises near the base, extending for about half the pronotal length; scutellum narrowly incised at the apex; elytra extending to the apex of the second abdominal segment, apically dehiscent, sparsely confusedly punctured, faintly rugose medially, the tips tumid and finely punctate, medial and subsutural costae are feebly evident; last ventral very narrowly incised at the apex.

Fema'e: Similar to the male; the eyes slightly smaller.

Holotype, male, Chiricahua Mountains, Arizona, September 12, 1947, D. J. & J. N. Knull; *allotype,* female and three *paratypes,* same data as the type but collected, September 5, 1947. Types in the Knull collection.

MALTHINUS SUBCOSTATUS Schaeffer

Plate II; figs. 14, 15

Malthinus subcostatus Schaeffer, Jour. N. Y. Ent. Soc. 16, 1903, p. 67.

Piceous to black; pronotum flavous, sometimes rather narrowly infuscate medially, this infuscate area widening near the base and apex; head obscurely paler to flavous in front of the antennae; elytral tips pale cream yellow; apical margins of the ventral abdominal segments rather widely pale; bases and apices of the trochanters, femora and tibiae more or less narrowly paler; pubescence cinereous, fine and inconspicuous. Length 3.5 to 4 mm.

Male: Head half again as wide as the pronotum, finely closely granulate; eyes large and prominent; antennae slender, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about six times as long as wide; pronotum transverse, widest slightly in front of the middle, the anterior angles rounded, the sides angulately rounded to the hind angles which are obtuse, marginal bead moderately thick, the disc finely sparsely punctured; elytra extending to the apex of the second abdominal segment, apically dehiscent, sparsely diffusely punctured and feebly rugose to the tips which are tumid and very finely, more closely punctate; sixth ventral abdominal segment widely deeply emarginate, the seventh ovate, a pair of spinose processes extend beyond the apex of the seventh.

Female: Similar to the male; eyes small and not prominent; antennae extending to half way between the elytral tips and the tips of the abdomen, the intermediate segments about six times as long as wide; hind angles of the pronotum rather widely reflexed; a medial and subsutural costae is evident on each elytron.

Described from the Huachuca Mountains, Arizona; specimens have been studied from Chiricahua Mountains, Santa Rita Mountains and Pinal Mountains of Arizona.

Malthinus tricolor new species

Head except the eyes, pronotum, basal half of the first antennal segment and the scutellum rufous; eyes black; remainder of the antennae nigropiceous; elytra piceous with the tips a creamy yellow and the bases widely rufous, the lateral and sutural margins narrowly pale; body beneath testaceous, the abdomen becoming infuscate apically; coxae, trochanters, femora and basal fourth to half of the tibiae flavous; apices of the tibiae and the tarsi fuscous; pubescence cinereous, fine and inconspicuous. Length 4.5 to 5 mm.

Male: Unknown.

Female: Head large, wider than the pronotum, finely coarsely punctured, more coarsely so at the sides behind the eyes; eyes moderately large and prominent; antennae slender, extending to the tip of the abdomen, segments two to four progressively longer, the intermediate segments about five times as long as wide; pronotum strongly transverse, about half again as long as wide, the anterior angles rounded, the sides straight, converging slightly to the hind angles which are obtuse, marginal bead thick, the disc finely sparsely punctate; scutellum shallowly notched apically; elytra extending to about the middle of the second abdominal segment, apically dehiscent, sparsely confusedly punctured, discal and subsutural costae feebly raised, more evidently indicated by margining series of punctures, the apices tumid and finely punctured.

Holotype, female, St. Xavier Mission, Tucson, Arizona, July 29, 1924, E. P. Van-Duzee; *Paratypes:* 1, same as type but collected August 12, 1924; 1, same as type but collected by J. O. Martin. Type in the collection of the California Academy of Sciences.

MALTHINUS BICOLOR (LeConte)

Plate II; figs. 16-19

Malthodes bicolor LeConte, Trans. Am. Ent. Soc. 12, 1884, p. 22.

Black; head, pronotum, scutellum and base of the first antennal segment red; scutellum narrowly infuscate apically; elytral apices olivaceous; abdomen sometimes fuscotestaceous basally; pubescence cinereous. Length 3 to 4.5 mm.

Male: Head large and round, obliquely narrowed behind the eyes which are prominent, somewhat tumid in the middle of the vertex, finely closely punctate; antennae slender, extending beyond the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four times as long as wide, somewhat flattened beyond the third segment; pronotum moderately transverse, the anterior angles obliquely truncated and strongly reflexed, the sides feebly bisinuately parallel to the hind angles which are obtusely rounded, marginal bead thick, the posterior margin slightly protuberant medially, disc smooth, virtually impunctate; scutellum triangularly notched apically; elytra short, slightly more than twice the length of the pronotum, finely sparsely confused punctate, becoming rugose medially and finely punctured and tumid at the tips, subcostate, the costae more pronounced by margining rows of deeper punctures, a row of similar punctures near the suture; sixth ventral broadly deeply emarginate, the base of the emargination widely truncated; seventh ventral stout, elongate, apically subtruncate; last

dorsals somewhat prolonged, otherwise normal; a ventral accessory process, connected to the apical third of the seventh ventral and on the dorsal side of that segment, widened apically, the apical margin deeply bisinuate as viewed ventrally, laterally ovate, hinged in such a manner that in rest it may be drawn in under the overhang of the penultimate dorsal.

Female: Similar to the male; antennae extending to slightly beyond the elytral apices; eyes not as prominent, the head smaller.

Described from the Huachuca Mountains of Arizona, specimens of this species have been seen from that area and the Santa Rita Mountains of Arizona.

LeConte was apparently uncertain as to the proper position of his species: "By the form and sculpture of the prothorax, this species seems intermediate between *Malthinus* and *Malthodes*." Mr. Floyd Werner kindly sketched the terminalia of the type. Specimens have been studied that conformed in every way with Mr. Werner's sketches and in these specimens the mandibles were toothed inwardly, therefore this species must be transferred to the genus to which it is now assigned.

Malthinus huachucae new species

Plate II; figs. 20, 21

Head, pronotum, scutellum and basal third of the first antennal segment red; palpi, eyes and the rest of the antennae black; elytra black with the apices olivaceous; body beneath brunneous; legs black; pubescence cinereous, fine, short and rather thick. Length 3.5 to 4 mm.

Male: Head wider than the pronotum, opaque, finely closely punctured; eyes small, strongly convex and prominent; antennae slender, extending to a little beyond the tips of the elytra, segments three and four equal, the second shorter, the intermediate segments about three and a half times as long as wide; pronotum transverse, the anterior angles rectangular, the sides nearly straight and parallel to the hind angles which are obtusely rounded, the basal margin arcuate, marginal bead thick, disc shining, finely sparsely punctured; elytra short, extending to the base of the second abdominal segment, not apically dehiscent, finely confusedly punctured basally, becoming rugose punctate medially, the tips tumid and finely sparsely punctured, a rather feebly defined discal costa on each, a rather deep marginal stria arising near the basal fourth and extending to about the apical fourth on the outer margin; male last ventrals short, transverse, the sixth narrowly rather shallowly notched medially, the seventh ventral narrower, the apex medially three lobed, the median lobe longest; last dorsal bifid, projected beyond the seventh ventral, each portion sinuately truncated apically.

Female: Similar to the male; sides of the pronotum feebly arcuate, converging slightly to the obtusely rounded hind angles.

Holotype, male; *allotype,* female and one *paratype,* Huachuca Mountains, Arizona. Types in the collection of the United States National Museum.

Frostia new genus

Head usually as narrow as or narrower than the pronotum, transversely concave in front of the eyes which are small, the outer margin of the mandibles inflexed, the inflexed portion having an acute tooth medially (Plate I, fig. 3); pronotum transverse, the sides widely reflexed, the disc with rather wide, moderately deep depressions, elytra abbreviated, more evidently so in the females; species winged, alate or both, in the latter instance the male is winged whereas the female is alate; lateral spinose processes of the male terminalia prominent, extending beyond the seventh ventral. Genotype, *Frostia laticollis* (LeConte).

KEY TO SPECIES

1. Pronotum flavous, the anterior angles infuscate ..... *laticollis*
   Pronotum piceous or black with at most the apical and basal margins narrowly pale 2
2. Basal one or two antennal segments pale 3
   Antennae entirely black or piceous 4
3. Pronotal disc biimpressed, basal two antennal segments pale, sixth ventral of the male shallowly emarginate ..... *impressus*
   Pronotum with a broad median impression, basal antennal segment pale, sixth ventral of male deeply emarginate ..... *malkini*
4. Wings of both sexes rudimentary, pronotum with a large U-shaped impression, seventh ventral of male larger, apically angulate, lateral spinose processes armed with two acute teeth beneath ..... *bidentatus*
   Wings of female rudimentary, of male well developed, pronotum biimpressed, seventh ventral small, apically rounded, lateral spinose processes abruptly bent down at the tip ..... *reflexus*

FROSTIA LATICOLLIS (LeConte)

Plate III; figs. 26, 28

Malthodes laticollis LeConte, Proc. Acad. Nat. Sci. Phila. 1861, p. 351. *Malthodes laticollis* LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 60. *Malthodes laticollis* Fall, Ann. Ent. Soc. Am. 12, no. 1, 1919, p. 34.

Piceotestaceous; head black behind the antennae, pale in front, the antennae fuscous with the basal segment pale; pronotum yellow with the anterior angles infuscate; elytral apices obscurely paler; trochanters, apices of the coxae and the femora of the front and hind legs and the bases of all tarsi paler; sides of the basal five abdominal segments widely pale; pubescence cinereous, sparse and inconspicuous. Length 2 to 2.5 mm.

Male: Head rounded, slightly wider than the pronotum, finely very sparsely punctured, the eyes comparatively small; antennae moderately stout, extending almost to the tips of the wings in repose, the second and third segments equal, the fourth segment slightly longer, the intermediate segments about three times as long as wide; pronotum transverse, the anterior angles rounded, the sides concavely converging slightly to the hind angles which are nearly rectangular, the sides rather widely reflexed at the angles, marginal bead thick on the base, becoming finer on the sides and nearly obsolete on

the anterior margin, the disc finely rather closely punctured, biimpressed; elytra rather finely rugose punctate, more evidently so apically.

Female: Similar to the male; head and eyes comparatively smaller; antennae shorter, the intermediate segments about twice as long as wide; pronotal impressions shallower, occasionally poorly defined.

Male terminalia: Ventral view; seventh ventral arcuately narrowing, rounded into the apex which is triangularly emarginate medially; seventh ventral small, semicircular, much shorter than the sixth; a produced central piece, pale in color, with a fine terminal filament; lateral spiniform processes produced diagonally towards the rear, apically acute. Lateral view; seventh ventral short; median process with a thin laminate keel beneath, the terminal filament curved; lateral spiniform processes moderately stout basally, sinuately narrowed to the tip which is acute and strongly bent up.

This species appears to be confined to California south of the San Gabriel and San Bernardino Mountains. Specimens have been seen from the following California localities: Keen Camp, Palm Springs, Palm Canyon, Pasadena, Cole and the San Bernardino Mountains.

Frostia impressus new species

Plate III; figs. 29-31

Piceous; mandibles, basal two segments of the antennae and basal margin of the pronotum pale; elytral apices piceotestaceous; trochanters, apices of the coxae and bases and apices of the femora and tibiae pale; sides and apices of the ventral abdominal segments widely pale, the apical segments becoming entirely testaceous, pubescence cinereous, rather long and conspicuous. Length 2.5 mm.

Male: Head as wide as the pronotum, finely sparsely punctured; eyes large and prominent for the genus; antennae moderately stout, extending to the tip of the abdomen, segments two and three equal, the fourth longer, the intermediate segments about three times as long as wide; pronotum strongly transverse, the anterior angles slightly produced and widely reflexed, the sides converging slightly to the hind angles which are obtuse, marginal bead thick, disc finely rather closely granulose, an elongate and rather broad impression on each side near the middle, extending for two thirds the length of the pronotum, an eroded median longitudinal impressed line, extending from the apical margin to the apical third of the pronotum; elytra extending to the apex of the fifth abdominal segment, sparsely punctured basally, becoming finely rugose towards the apices, the tips tumid and finely punctured.

Female: Similar to the male; head narrower than the pronotum; antennae extending to the middle of the elytra, the intermediate segments about twice as long as wide; wings fully developed.

Male terminalia: Ventral view; sixth ventral short, transverse, shallowly triangularly emarginate; seventh ventral short, narrow and semicircular; a median narrow process with a fine apical filament. Lateral view; seventh

ventral short, concealed by the sides of the sixth; median accessory process short, laminate with an arcuately ascending apical filament; lateral spiniform processes straight, parallel sided basally, narrowed apically from the middle to the tip which is sharply rounded.

Holotype, male; *allotype*, female, Hullville, Lake County, California, June 15, 1917, F. E. Blaisdell; one *paratype*, Huntington, Lake County, California. Types in the collection of the California Academy of Sciences.

Frostia malkini new species

Plate III; figs. 32-34

Black; mandibles and basal segment of the antennae pale; apices of the coxae, trochanters, apices of the femora and bases of the tibiae obscurely paler; basal margin of the pronotum sometimes paler; apical median accessory organ of the male terminalia flavous; pubescence cinereous and inconspicuous. Length 2 to 2.5 mm.

Male: Head transverse, as wide as or slightly wider than the pronotum, finely rather sparsely punctured; eyes small, moderately prominent; antennae slender, extending nearly to the tips of the wings in repose, segments two and four equal, the third slightly shorter, the intermediate segments about four and a half times as long as wide; pronotum strongly transverse, the anterior angles rather sharply rounded, the sides strongly convergent to the hind angles which are obtuse, marginal bead thick, the sides widely reflexed, disc moderately closely punctate, broadly impressed medially, this impression nearly circular; elytra extending to the apex of the fifth abdominal segment, finely rugose punctate basally, becoming a little more coarsely so apically.

Female: Similar to the male; basal antennal segment not paler, the pronotum brunneous with a small discal spot and the margins infuscate; head rounded with the eyes less prominent; antennae shorter with the intermediate segments about three and a half times as long as wide; the median impression of the pronotum evident but not as prominently so.

Male terminalia: Sixth ventral narrowly deeply emarginate, the base of the emargination angulate; seventh ventral barely projected beyond the sides of the sixth, the apex widely rounded, the median apical accessory process acute at the tip. As viewed laterally; last dorsal segment subtruncately rounded; seventh ventral straight, protruding slightly, the tip of the median accessory process sharply deflexed; spiniform lateral processes stout basally, narrowing rather rapidly before the middle, the tip reflexed and acute.

Holotype, male; *allotype*, female and two male *paratypes*, Spencers Butte, Eugene, Oregon, May 25, 1947, Borys Malkin. Types in the collection of the California Academy of Sciences.

Frostia bidentatus new species

Plate III; figs. 35-37

Piceous; head and pronotum black, elytra medially, middle and hind tibiae and ventral abdominal segments piceotestaceous; pubescence cinereous, fine and short. Length 2 to 3 mm.

Male: Head as wide as the pronotum, finely punctate; eyes small and not prominent; antennae moderately stout, extending to the tip of the abdomen, second and fourth segments equal, the third shorter, the intermediate segments about two and a half times as long as wide; pronotum moderately transverse, the anterior angles obliquely truncated and rather widely reflexed, the sides converging slightly to the obliquely rounded hind angles, marginal bead moderately thick, the disc rather coarsely closely punctured, a wide deep U-shaped median impression; elytra finely sparsely punctured basally, becoming feebly rugose punctate apically; wings atrophied, not extending beyond the elytral apices.

Female: Unknown or unrecognized in the available material.

Male terminalia: Ventral view; sixth ventral shallowly angulately incised; seventh ventral obliquely quadrilateral, slightly keeled beneath; apical accessory process acute at the tip which bears a thin laminate extension. Lateral view; seventh ventral large, subtriangular, the free angle rounded; ultimate dorsal short, transverse and apically truncate; median accessory process apically acute, the ventral surface sinuate at the apex, a thin laminate extension sinuately ascending apically; lateral spiniform processes apically narrowed and bidentate beneath.

Holotype, male, Carmel, California, May 14, 1921. *Paratypes:* 3, Pygmy Forest, Fort Bragg, Mendocino County, California, June 14, 1948, H. B. Leech; 1, Blair's Ranch, Redwood, Humboldt County, California, June 19, 1903, H. S. Barber; 1, Bryson, California, April 25, 1917, E. P. VanDuzee. Type in the collection of the California Academy of Sciences.

FROSTIA REFLEXUS (Fall)

Plate III; figs. 38-40

Malthodes reflexus Fall, Ann. Ent. Soc. Am. 12, no. 1, 1919, p. 34.

Piceous; head black, bases of the mandibles and frequently the apical and basal margins of the pronotum narrowly pale; elytral apices piceotestaceous; pubescence cinereous, short and conspicuous, especially so on the pronotum. Length 2 to 2.5 mm.

Male: Head as wide as the pronotum, finely rather sparsely punctured; eyes small and not very prominent; antennae moderately stout, extending to the elytral apices, segments two to four equal, the intermediate segments about two and a half times as long as wide; pronotum strongly transverse, the anterior angles obliquely truncated and somewhat produced, the sides concave, converging to the hind angles which are obtusely rounded, marginal bead thick, the disc closely rather coarsely granulate, biimpressed, each impression about one half the pronotal length; elytra extending to the apex of the fifth abdominal segment, finely rugose punctate to the tips which are tumid and finely punctured.

Female: Similar to the male; head conspicuously narrower than the pronotum, the eyes smaller and less prominent; pronotum strongly transverse, the anterior angles obliquely truncated, not produced, the sides straight, con-

verging to the hind angles which are rounded; elytra short, extending slightly beyond the first abdominal segment; wings wanting.

Male terminalia: Ventral view; sixth ventral narrowly triangularly incised apically; seventh ventral semicircular, the median process produced slightly beyond the seventh and bearing an apical filament; lateral spiniform processes produced slightly beyond the seventh ventral, the tips feebly bent out. Lateral view; seventh ventral straight; median accessory process elongate with a laminate keel beneath and an apical sinuate filament; lateral spiniform processes sharply deflexed at the tips which are acute.

Fall's type was collected in Marin County, California. The other members of the type series were from Fairfax (Marin County), Vine Hill (Contra Costa County) and Niles Canyon, California. Additional specimens have been examined from Los Gatos and Carmel, California, the latter locality being the most southerly record known to date.

MALTHODES Kiesenwetter

Kiesenwetter, Linnaea 6, 1852, pp. 239-324.

Head transversely concave in front of the eyes (Plate I, fig. 4), the mandibles simple (Plate I, fig. 5) or inwardly finely serrate (Plate I, fig. 6); antennae filiform, long; pronotum quadrate to transverse, the basal margin usually shorter than the apical margin, the sides more or less convergent basally; elytra abbreviated, parallel sided, the tips individually rounded, confusedly punctured, usually becoming rugose punctate apically, the tips may or may not be tumid and finely sparsely punctured; male terminalia fairly simple to intricate, variously modified, these modifications exposed; female apical abdominal segments monotonously similar, the sixth ventral narrowly deeply emarginate apically.

KEY TO GROUPS*

1. Last dorsals normal or produced in a normal manner 2
   Last dorsals modified, either apically or laterally 8
2. Sixth ventral strongly inflated, nearly encompassing last dorsals .....Group VI, p. 561
   Sixth ventral normal 3
3. Seventh ventral oblong ovate (feebly emarginate in one species); accessory processes usually exposed .....Group XII, p. 602
   Seventh ventral not oblong ovate 4
4. Seventh ventral apically subacute .....Group II, p. 547
   Seventh ventral apically forked, notched or truncate 5
5. Seventh ventral deeply channeled, i.e. V-shaped in cross section .....Group III, p. 550
   Seventh ventral not deeply channeled 6
6. Seventh ventral forked for one half or more of its length .....Group IV, p. 552
   Seventh ventral not forked for one half or more of its length 7
7. Seventh ventral thin in vertical diameter .....Group I, p. 529
   Seventh ventral thick, terete .....Group V, p. 556
8. Last two or three dorsals prolonged medially, narrowed and strongly arched 9
   Last two or three dorsals normal medially, side pieces of penultimate dorsal produced caudad, ventrad or both 10

9. Ultimate dorsal with a median keel on the ventral side, tip not received in the fork of the seventh ventral ..... Group VII, p. 563
Ultimate dorsal not keeled on the ventral side, tip usually received in the fork of the seventh ventral ..... Group VIII, p. 567
10. Seventh ventral evenly bisinuate in profile ..... Group IX, p. 572
Seventh ventral not bisinuate in profile 11
11. Produced side pieces of penultimate dorsal projecting ventrad or ventrad then caudad ..... Group X, p. 575
Produced side pieces of penultimate dorsal projecting caudad, sometimes with the tips bent ventrad ..... Group XI, p. 597

GROUP I

1. Seventh ventral apically expanded, the tip bisinuately emarginate 23
Seventh ventral apically narrowed or parallel sided (feebly dilated apically in one species) 2
2. Seventh ventral truncate or rounded apically 21
Seventh ventral apically notched or emarginate 3
3. Tips of seventh ventral rounded 4
Tips of seventh ventral angulate 13
4. Seventh ventral straight in profile 5
Seventh ventral not straight in profile 8
5. Basal two antennal segments pale ..... *cordicaudus*
Basal two antennal segments piceous 6
6. Sides of seventh ventral parallel to tips ..... *fracidus*
Seventh ventral narrowed apically 7
7. Sides of seventh ventral straight to the tips ..... *evanidus*
Sides of seventh ventral curved to tips ..... *spado*
8. Seventh ventral apically bent ventrad ..... *piceolus*
Seventh ventral not apically bent ventrad 9
9. Seventh ventral apically ascending 10
Seventh ventral sinuate 11
10. Basal two antennal segments pale, pronotum flavous with a faint fuscous discal cloud to fuscous with the basal and apical margins narrowly pale ..... *basalis*
Basal two antennal segments piceous, pronotum with the anterior angles and a median longitudinal stripe infuscate ..... *piciithorax*
11. Seventh ventral chordate in outline ..... *mackenzei*
Seventh ventral evenly narrowed from base to apex 12
12. Pronotum flavous, eyes very large, separated frontally by not more than their own horizontal width ..... *vigilans*
Pronotum piceotestaceous, eyes normal, separated frontally by more than one and a half times their own horizontal width ..... *columbiensis*
13. Seventh ventral straight in profile 14
Seventh ventral sinuate or apically bent in profile 16
14. Testaceous to flavous, the elytra piceous, becoming paler medially ..... *rectus*
Piceous or black, the pronotum flavous, either with or without maculations 15
15. Piceous, the pronotum and basal two antennal segments flavous ..... *glyphidius*
Black, the pronotum flavous with the anterior margin and a median longitudinal stripe infuscate ..... *pictus*
16. Seventh ventral apically bent ventrad ..... *insipidus*
Seventh ventral sinuate or apically ascending 17
17. Seventh ventral apically ascending 18
Seventh ventral sinuate 19

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* The keys to the species of this genus are based almost exclusively on the terminal abdominal segments of the males.

18. Seventh ventral parallel sided, the apex narrowly shallowly emarginate ..... *arizonensis*
Seventh ventral apically narrowed, the sides arcuate, the apex triangularly notched ..... *albimontanus*
19. Sides of seventh ventral sinuate, subparallel ..... *fragilis*
Sides of seventh ventral arcuately narrowed apically 20
20. Seventh ventral shallowly triangularly emarginate, the eyes large and prominent, separated anteriorly by little more than their own diameter ..... *mitificus*
Seventh ventral shallowly concavely emarginate, eyes of normal size, separated frontally by about twice their own diameter ..... *knowltoni*
21. Seventh ventral slightly expanded apically, the tip subtruncately rounded ..... *chapini*
Seventh ventral narrowed apically, truncate 22
22. Seventh ventral extending beyond the sixth for one half its length ..... *adoxus*
Seventh not or scarcely extending beyond the tips of the sixth ..... *truncatus*
23. Apex of seventh ventral three lobed, the lobes short, last dorsal normal; piceo-testaceous, the sides of the pronotum paler ..... *tribulus*
Apex of seventh ventral bisinuate, last dorsal thin, folded down against the apex of the penultimate, dorsal, the apex triangularly bent. Bluish black to feebly aeneous, the pronotum flavous ..... *atrocoeruleus*

Malthodes cordicaudus new species

Plate III; figs. 41, 42

Head black with the clypeus and mandibles flavous; antennae piceous with the basal two segments flavous; pronotum flavous with the anterior angles narrowly infuscate; elytra piceous; front legs piceous, the tibiae and bases and apices of the femora pale, the middle and hind legs piceous with the apices of the femora and bases of the tibiae rather narrowly pale; abdomen piceous, the basal segment widely pale at the sides, the intermediate segments narrowly pale apically and at the sides; pubescence cinereous and inconspicuous. Length 2.5 to 3 mm.

Male: Head wider than the pronotum, finely sparsely granulate behind the antennae; eyes moderately prominent; antennae moderately stout basally, becoming more slender apically, extending to about half way between the elytral apices and the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four and a half times as long as wide; pronotum moderately transverse, the anterior angles rounded, the sides arcuate, converging slightly to the hind angles which are feebly prominent, marginal bead fine, disc finely sparsely punctured; elytra short, extending to the apex of the fourth abdominal segment, very finely rugose punctate.

Female: Head narrower than the pronotum; antennae stout, extending to the tips of the elytra, the intermediate segments about twice as long as wide; elyra shorter, extending to about the apex of the third abdominal segment.

Male terminalia: Ventral view; sixth ventral narrow, nearly as long as wide, deeply emarginate, the base of the emargination obscured by the overlap of the fifth ventral; seventh ventral elongate, stout, sides expanded medially, the tips rounded evenly into the shallowly, triangularly notched apex making the segment appear elongate cordate. Lateral view; seventh ventral straight, the dorsal and ventral surfaces nearly parallel to the apex which is rounded; last dorsals slightly prolonged, otherwise normal.

Holotype, male and *allotype*, female, French Glen, Oregon, June 14, 1947, K. M. Fender, in the collection of the California Academy of Sciences.

Malthodes fracidus new species

Plate III; figs. 43, 44

Black; pronotum either black or flavous; mandibles and the apices of the intermediate abdominal segments narrowly paler; pubescence cinereous and inconspicuous. Length 3 to 3.5 mm.

Male: Head wider than the pronotum, finely punctured behind the eyes which are prominent; antennae moderately stout, extending to about half way between the tips of the elytra and the tips of the wings in repose, the second and third segments equal, the fourth evidently longer, the intermediate segments nearly five times as long as wide; pronotum moderately transverse, the anterior angles obliquely rounded, the sides nearly straight and parallel to the hind angles which are prominent, the sides widely reflexed, especially so at the anterior angles, marginal bead thick, the disc finely rather closely punctured; elytra rather short, extending to the apex of the fourth ventral, finely rugose punctate.

Female: Similar to the male, the head slightly wider than the pronotum, antennae extending nearly to the tips of the elytra, the intermediate segments about three and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral narrow, the apex deeply narrowly emarginate, the base of the emargination evenly rounded; seventh ventral elongate, stout, extending beyond the sixth by about the length of that segment, sides parallel, the tips evenly rounded into the shallow acute apical notch. Lateral view; seventh ventral straight, unusually stout, rounded at the apex; last dorsal slightly extended, otherwise normal.

Holotype, male; *allotype*, female and 20 *paratypes*, Donner Pass, California, June 9, 1947, K. M. Fender; 2 *paratypes*, Fallen Leaf Lake, Eldorado County, California, July 3, 1935, F. E. Blaisdell.

This species is unique in that the pronotum may be either entirely black or entirely flavous. No intermediates have been seen. Each color variety was about equally represented in the Donner Pass material all of which was collected from the same group of trees, an undetermined species of Pinus. No pairs were taken in coitu but the lack of other differentiating characters than color for separation suggests that but one species is represented.

Malthodes evanidus new species

Plate III; figs. 45, 46

Black; bases of the mandibles, bases and apical margins of the pronotum and apices of the basal abdominal segments at the sides narrowly pale; pubescence cinereous and inconspicuous. Length 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes moderately large and prominent; antennae moderately stout, extending to the tips of the wings in repose; segments two to four pro-

gressively longer, the intermediate segments about four and a half times as long as wide; pronotum moderately tranverse, the anterior angles rounded, the sides sinuate and converging slightly to the hind angles which are obtuse, the anterior angles reflexed, marginal bead fine, disc finely rather sparsely granulate; elytra extending to the apex of the fourth ventral, finely sparsely punctured basally, becoming rugose punctate apically.

Female: Similar to the male; head just visibly wider than the pronotum; eyes less prominent; margins of the pronotum more widely pale; pubescence a little more conspicuous.

Male terminalia: Ventral view; sixth ventral narrowed apically, the apex emarginate nearly to the base, the base of the emargination acutely angled; seventh ventral elongate, stout, extending beyond the sixth by about the length of the sixth, the sides straight, converging somewhat to the apex which is shallowly notched, the tips sharply rounded. Lateral view; sixth ventral subquadrate; seventh ventral straight, the ventral surface straight, the dorsal surface arcuate from the base to the apex which is sharply rounded; last dorsals extended to the tips of the seventh ventral; apical margin of the penultimate dorsal rounded.

Holotype, male; *allotype,* female and 11 *paratypes,* Duck Creek Forest Camp, Dixie National Forest, Utah, 8000 feet, June 16, 1947, C. P. Alexander, types in the collection of the California Academy of Sciences.

MALTHODES SPADO LeConte

Plate IV; figs. 47, 48

Malthodes spado LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 60.

This species is not represented in the available material nor has any specimen been seen. Mr. Floyd Werner kindly cleaned and studied the type, carefully sketching the terminalia. The figures of this species are rather diagrammatic copies of Mr. Werner's sketches and should be considered on this basis. LeConte's description is brief and inadequate being only a portion of a synoptic review. "Last abdominal segments normal in both sexes. Piceous tinged with testaceous, prothorax nearly twice as long as wide, sides finely margined, more strongly so near and at the sides of the base; elytra two-thirds the length of the wings; male head wider than prothorax, eyes small, prominent, antennae extending behind the elytra, as long as the wings, second joint equal to third, penultimate ventral segment emarginate, last segment triangular, rounded at tip. Length 2 to 3 mm.; Pa.; Ga."

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, narrower than the fifth, the base of the emargination rounded; seventh ventral stout, extending beyond the sixth by about one half the length of the sixth, triangularly rounded, the apex narrowly shallowly notched. Lateral view; seventh ventral straight, narrowed apically, the tip truncate; penultimate dorsal short, feebly diagonal; ultimate dorsal not exposed; a short ventral accessory process arises near the seventh ventral, slightly descending apically.

MALTHODES PICEOLUS Fall

Plate IV; figs. 49, 50

Malthodes piceolus Fall, Ann. Ent. Soc. Am. 12, no. 1, 1919, p. 37.

Piceous; mandibles, apex of the clypeus and apical and basal margins of the pronotum pale; the pronotum tinged with brunneous, especially towards the sides; articulations of the legs narrowly feebly pale; basal abdominal segments fuscotestaceous, gradually darkening to black on the apical segments; pubescence cinereous, inconspicuous. Length 2.5 to 3 mm.

Male: Head evidently wider than the pronotum, finely sparsely granulate behind the antennae; eyes moderately prominent; antennae moderately stout, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum moderately transverse, the anterior angles obliquely rounded, the sides straight, converging slightly to the obtusely rounded hind angles, the anterior margin shallowly indented medially, the anterior angles very narrowly reflexed, marginal bead fine, the disc finely closely granulate; elytra finely rugose punctate for their entire length.

Female: Similar to the male; head narrower than the pronotum; antennae shorter, the intermediate segments about three times as long as wide.

Male terminalia: Ventral view; sixth ventral narrowed apically, deeply emarginate, the base of the emargination sharply rounded; seventh ventral elongate, stout, extending beyond the sixth by about one half the length of that segment, sides feebly arcuately converging to the tip which is shallowly incised, the tips rounded. Lateral view; seventh ventral slightly deflexed at the tips which is sharply rounded; last dorsals normal.

Fall's type series was collected at Green Point, Humboldt County, California by F. E. Blaisdell. Three specimens of this series have been studied. Over a hundred additional specimens have been examined from: British Columbia; Creston and North Bend. Washington; Vancouver. Oregon; Portland, McMinnville and Dayton. California; Mokelumne Hill, Green Point (Humboldt County).

This species has the greatest known range of any of the Pacific Slope species. It varies from the described form which is the paler California variety to entirely black which is more typical of the British Columbia series.

MALTHODES BASALIS Fall

Plate IV; figs. 51, 52

Malthodes basalis Fall, Ann. Ent. Soc. Am. 12, no. 1, 1919, p. 36.

Fuscous; head in front of the eyes, basal two segments of the palpi, basal two segments of the antennae, pronotum and the front legs except for a small median portion of the femora flavous; of the middle and hind legs, the trochanters, apices of the coxae, apices and bases of the femora and tibiae and the base of the first tarsal segment pale; abdomen reddish testaceous with the

intermediate segments yellowish apically; pubescence cinereous. Length 2.5 to 5 mm.

Male: Head wider than the pronotum, finely sparsely granulate behind the antennae; eyes prominent; antennae moderately stout, second and third segments equal, the fourth considerably longer, the intermediate segments about four and a half times as long as wide; pronotum moderately transverse the anterior angles obliquely truncated, the sides straight, converging slightly to the obtusely rounded hind angles, rather narrowly reflexed at the angles, marginal bead thick, disc finely sparsely granulate; elytra finely rugose punctate, the tips feebly tumid and finely punctured.

Female: Similar to the male; head and pronotum rather closely granulose; antennae extending to the apices of the elytra, the intermediate segments about three times as long as wide; abdomen fuscous, the intermediate segments widely pale apically.

Male terminalia: Ventral view; sixth ventral extremely narrow with the sides straight and converging to the apex which is narrowly emarginate, the base of the emargination acutely rounded; sides of the seventh ventral straight, converging to the tips which are sharply rounded into the apex which is rather widely shallowly incised. Lateral view; sixth ventral extending upward and backward, becoming somewhat acuminate apically; seventh ventral straight, parallel sided, slightly ascending from the point of emergence from the sixth, straight to the apex which is evenly rounded; last dorsal slightly extended, otherwise normal.

Previously recorded from Nevada and California, specimens have been studied from Oregon and Utah extending the known range to these states. The type was collected at Yosemite, California by W. M. Giffard and part of the type series has been examined. Available specimens are from: California; Yosemite (type material), Licking Fork (Mokelumne River), Los Gatos (Humboldt County), Fallen Leaf Lake (El Dorado County), Murphys (Calaveras County), Ahwahnee, Alpin Creek, Tahoe. Oregon; Corvallis. Utah; Ogden, Utah Lake.

Malthodes pictithorax new species

Plate IV; figs. 53, 54

Piceous; head darker with the clypeus and mandibles flavous; pronotum yellow, the anterior angles narrowly infuscate, often with a median elongate fuscous spot on the disc; apices of the coxae and trochanters and basal abdominal segments paler; pubescence cinereous, inconspicuous. Length 3 to 3.5 mm.

Male: Head slightly wider than the pronotum, finely sparsely punctured behind the antennae; eyes moderately large and prominent; antennae extending well beyond the tips of the wings in repose, the second and third segments equal, the fourth evidently longer, the intermediate segments about four and a half times as long as wide; pronotum transverse, the anterior angles obliquely rounded and rather reflexed, the sides sinuate to the hind angles which are

rounded, marginal bead fine, disc finely sparsely granulose; elytra finely punctured basally, becoming rugose medially, the apices feebly tumid and finely punctured.

Female: Similar to the male; antennae extending to the apical fifth of the elytra, the intermediate segments about three and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral narrowly deeply emarginate, the base of the emargination rounded; seventh ventral moderately elongate, stout, extending beyond the sixth by about the length of the sixth, the apex shallowly triangularly notched, the tips rounded. Lateral view; sixth ventral short; seventh ventral slightly ascending; last dorsals normal.

Holotype, male; *allotype,* female and three *paratypes,* Lompoc, California, May 22, 1945, on alfalfa, types in the collection of the United States National Museum. *Paratypes:* 2, Lafayette, California, May 24, 1940; Chester, California, July 7, 1948; 1, same but collected June 30, 1948; 4, Los Angeles County, California; 3, Wilsonia, Tulare County, California, August 8, 1945; 1, Hamilton, Santa Clara County, California, June 15, 1947.

Malthodes mackenziei new species

Plate IV: figs. 55, 56

Nigropiceous; mandibles testaceous; legs slightly paler than the body; anterior margin of the pronotum narrowly flavous, extensive flavous areas extending inwardly from the basal angles for about a third of the pronotal width and forward to about the middle; first visible abdominal segment widely pale at the sides, apices of the elytra piceotestaceous; pubescence cinereous, fine and sparse. Length 2.75 to 3.25 mm.

Male: Head slightly wider than the pronotum, finely sparsely punctured, the antennal pits strongly oblique; eyes small, separated frontally by twice their own horizontal diameter; antennae moderately slender, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum moderately transverse, the anterior angles obliquely rounded and narrowly reflexed, the sides straight, converging slightly to the hind angles which are obtuse, marginal bead fine, disc finely sparsely punctured; elytra extending to the apex of the second abdominal segment, finely punctured basally, becoming finely rugose to the tips which are tumid and finely punctured.

Female: Pronotum flavous with the anterior angles infuscate; head slightly narrower than the pronotum; eyes smaller; antennae extending to about the apex of the third abdominal segment, the intermediate segments about three times as long as wide.

Male terminalia: Ventral view; sixth ventral narrowed apically, narrowly deeply emarginate, the base of the emargination angulate; seventh ventral elongate, stout, extending beyond the sixth by about one-half the length of the sixth, sides expanded, the tips evenly rounded into the apex which is moderately angulately notched giving the segment the appearance of being chordate. Lateral view; seventh ventral sinuate, slightly expanded apically then narrowed to the tip which is angulate near the ventral surface; last dorsals slightly prolonged, otherwise normal.

Holotype, male; *allotype*, female and eight *paratypes*, Lake Arrowhead, California, June 30, 1943, G. P. MacKenzie. Types in the collection of the California Academy of Sciences. *Paratypes:* 2, Santa Rita Mountains, Arizona, June 21; 7, Santa Rosa Mountains, California; 13, Trent, Utah.

This species is closely related to *M. cordicaudus* with which it agrees in its cordiform seventh ventral. It may readily be separated from that species by the color of the pronotum and the seventh ventral sinuate in profile.

MALTHODES VIGILANS Fall

Plate IV; figs. 57, 58

Malthodes vigilans Fall, Ann. Ent. Soc. Am. 12, no. 1, 1919, p. 36.

Head black with the mandibles pale; pronotum flavous; antennae, elytra, legs and body beneath piceotestaceous; apices of the coxae and apices of the ventral abdominal segments narrowly pale; pubescence cinereous, moderately conspicuous. Length 4 to 4.5 mm.

Male: Head finely sparsely punctured behind the antennae, wider than the pronotum; eyes very large and prominent, separated frontally by but little more than their own horizontal diameter; antennae slender extending to the tips of the wings in repose, segments two to five progressively longer, the intermediate segments nearly five times as long as wide; pronotum transverse, the sides sinuate from the obliquely truncated anterior angles to the hind angles which are prominent, marginal bead thick, the disc finely sparsely punctured; elytra finely rugose punctate with the tips slightly tumid and finely punctured.

Female: Similar to the male; head as wide as the pronotum, more closely punctured; eyes smaller and less prominent; pronotal hind angles moderately prominent; intermediate segments of the abdomen pale.

Male terminalia: Ventral view; sixth ventral narrowed apically, narrowly deeply emarginate, the base of the emargination angulate; seventh ventral short and broad, projecting beyond the sixth by a little less than the length of the sixth, the apex narrowly deeply incised. Lateral view; seventh ventral sinuate, the apical third slender; last dorsals slightly enlarged and produced as far as the seventh ventral, otherwise normal.

This species was described from the San Bernardino Mountains, California. Specimens have been seen from Dalton Creek, Fresno County, California.

Malthodes columbiensis new species

Plate IV; figs. 59, 60

Piceous; head black, the front and mandibles obscurely paler; pronotum flavous with the anterior angles and margin infuscate, this infuscation becoming rather wide medially; apices of the coxae, bases of the trochanters and bases and apices of the femora and tibiae narrowly piceotestaceous; pubescence cinereous, short, sparse and inconspicuous. Length 3 to 3.5 mm.

Male: Head wider than the pronotum, finely sparsely granulate behind

the antennae; eyes moderately large and prominent; antennae slender, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about three and a half times as long as wide; pronotum transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides nearly straight, converging slightly to the hind angles which are prominent, marginal bead thick, becoming finer on the anterior margin, disc finely sparsely punctured; elytra rather short, extending to the apex of the fourth abdominal segment, finely punctured basally, more coarsely so medially, becoming rugose at about the apical third.

Female: Differing from the male in that the head is slightly wider than the pronotum, eyes smaller and less prominent; antennae extending to about the elytral apices, the intermediate segments about two and a half times as long as wide; pronotal infuscate areas narrower.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate (retracted and the base not visible); seventh ventral extending beyond the sixth by about the length of that segment, narrowed apically, the apex narrowly acutely nicked, the tips rounded. Lateral view; seventh ventral slender, feebly sinuate, the tips rounded; last dorsal slightly prolonged, otherwise normal.

Holotype, male; *allotype,* female and six *paratypes,* Creston, British Columbia, May 30, 1931, G. Stace Smith, types in the collection of the California Academy of Sciences.

MALTHODES RECTUS LeConte

Plate IV; figs. 61, 62

Malthodes rectus LeConte, Trans. Am. Ent. Soc. 19, 1881, p. 61.

Flavous; elytra and the head behind the eyes castaneous, the elytra obscurely paler medially; basal two antennal segments piceous; tarsi, medial portions of all tibiae and the terminal abdominal segments infuscate; pubescence piceous, sparse and inconspicuous. Length 2.75 to 3 mm.

Male: Head wider than the pronotum, very finely sparsely punctured; eyes small and moderately prominent; antennae stout basally, becoming more evidently slender apically, extending to a little beyond the elytral apices, segments two and three equal, the fourth slightly longer, the intermediate segments about three and a half times as long as wide; pronotum narrowly transverse, the anterior margin strongly arched, the anterior angles obliquely rounded and widely reflexed, the sides arcuate to the prominently rounded and widely reflexed hind angles, marginal bead fine, disc finely sparsely punctate; elytra finely punctured basally, becoming feebly rugose punctate towards the apices, the apical tumidities smooth and finely punctate.

Female: Similar to the male; head subequal to the pronotum; intermediate antennal segments about twice as long as wide.

Male terminalia: Ventral view; sixth ventral narrowly deeply emarginate, the base of the emargination sharply rounded; seventh ventral elongate, stout basally, narrowing to near the apex which has acute, widely divergent tips, the apical notch shallowly triangular. Lateral view; seventh ventral stout, straight,

narrowing to the angulate tip; penultimate dorsal large, prolonged to about the tip of the seventh ventral; last dorsal not exposed.

LeConte described this species from Virginia and Georgia. Specimens have been examined from Alabama: Mobile, Langdale (Chambers County), Jackson. Florida: Jacksonville. Georgia: St. Catherine Island.

Malthodes glyphidius new species
Plate IV; figs. 63, 64

Piceotestaceous; head in front of the eyes and the basal two antennal segments pale; pronotum and apices of the ventral abdominal segments flavous; pubescence cinereous, sparse and inconspicuous. Length 2.5 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae, the interantennal area strongly elevated above the interocular plane; eyes moderately prominent; antennae moderately stout, extending to the tips of the wings in repose, second and third segments equal, the fourth visibly longer, the intermediate segments about four and a half times as long as wide; pronotum moderately transverse, the anterior angles obliquely rounded, the sides nearly straight, converging slightly to the hind angles which are obtusely rounded, the marginal bead rather fine, the disc finely sparsely punctate; elytra finely punctured basally, becoming finely rugose apically to near the tips which are slightly inflated and smooth.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral narrowed apically, deeply emarginate, the base of the emargination hidden by the apex of the fifth in the type; seventh ventral broadly elongate, extending beyond the sixth by not quite the length of the sixth, sides converging apically, the apex broadly incised with the base of the incision obtusely angulate. Lateral view; seventh ventral straight, the tip rounded; last dorsals slightly extended, otherwise normal.

Holotype, male, Huntington, Oregon 1889, George H. Horn, in the collection of the California Academy of Sciences.

Malthodes pictus new species
Plate V; figs. 65, 66

Black; mandibles obscurely paler; pronotum flavous, the apical margin black, a median discal black spot extends from the apex to the base, widening at the apical third, diagonal black stripes arise basomedially and extend nearly half way to the anterior angles forming a widely spread V, triangular blackish areas at the sides extend from the basal third to and including the anterior angles; pubescence cinereous and inconspicuous. Length 3 mm.

Male: Head wider than the pronotum, finely moderately closely granulate behind the antennae; eyes prominent; antennae stout, extending to about half way between the elytral apices and the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four

times as long as wide; pronotum transverse, the anterior angles rounded, the sides narrowly reflexed, straight and parallel to the hind angles which are obtuse, marginal bead thick, the disc finely sparsely punctured; elytra short, extending to the apex of the third abdominal segment, rugose punctate.

Female: Similar to the male; pronotal markings generally more obscure; the eyes moderately prominent, the head visibly wider than the pronotum which is moderately transverse; intermediate antennal segments about three times as long as wide.

Male terminalia: Ventral view; sides of the sixth ventral rounded into the widely deeply emarginate apex making it widely bisinuate; seventh ventral elongate, stout, extending beyond the sixth by about the length of that segment, wide basally, the sides arcuately incurved to the apex which is triangularly notched, the notch not as deep as it is wide, the tips acute. Lateral view; seventh ventral straight, the tip sharp; ultimate dorsal slightly prolonged, subtruncately rounded apically.

Holotype, male and *allotype* female, Donner Pass, California, June 9, 1947, K. M. Fender, in the collection of the California Academy of Sciences.

Malthodes insipidus new species

Plate V; figs. 67, 68

Piceous; head black with the apex of the clypeus and the mandibles fuscous; pronotum flavous; sides of the first and apices of the intermediate abdominal segments narrowly pale; pubescence cinereous, inconspicuous. Length 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; apical segment of the maxillary palpi with an apical group of setigerous hairs causing the segments to appear aciculate; eyes prominent; antennae stout, extending to the tips of the wings in repose, segments two and three equal, the fourth evidently longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides straight, converging slightly to the feebly prominent hind angles which are narrowly reflexed, marginal bead thick, the disc finely sparsely punctured; elytra finely punctured basally, becoming rugose apically.

Female: Similar to the male; head as wide as the pronotum; eyes not as prominent; antennae extending to the tips of the elytra, the intermediate segments about three times as long as wide; pronotal sides slightly arcuate.

Male terminalia: Ventral view; fifth and sixth ventrals slightly inflated, the apex of the sixth deeply moderately widely emarginate, the base of the emargination evenly rounded; seventh ventral stout, elongate, extending beyond the sixth by about the length of the sixth, wide basally and narrowing rapidly to the rather narrow tip which is acutely notched, the notch being about as deep as the segment is wide at the tip. Lateral view; seventh ventral rod like, apically deflexed; penultimate dorsal normally extended, the ultimate a short median triangular process.

Holotype, male and *allotype* female, Keen Camp, California, June 14, 1946, D. J. and J. N. Knull, in the Knull collection. *Paratypes:* 7, Keen Camp, California, May 24, 1946; 6, Williams, Arizona, June 3 to July 9; 3, Chiricahua Mountains, Arizona, June 21 to 31; 1, Morrison, Arizona, no date.

Malthodes arizonensis new species

Plate V; figs. 69, 70

Black; antennae, tibiae and tarsi piceous; apical and basal margins of the pronotum very narrowly obscurely paler; apical tumidities of the elytra piceous; pubescence cinereous, fine and inconspicuous. Length 3.25 mm.

Male: Head broad, wider than the pronotum, finely closely granulose behind the antennae; eyes prominent; antennae stout basally, becoming slender apically, extending to the tips of the wings in repose, second segment slightly shorter than the third which in turn is about three fourths as long as the fourth, the intermediate segments slightly more than five times as long as wide; pronotum transverse, the anterior angles obliquely truncated, the sides concave to the prominent basal angles, the anterior angles narrowly reflexed, marginal bead fine, disc finely sparsely granulose; elytra rugose punctate with the tips tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; sides of the sixth ventral converging to the apex which is triangularly emarginate, the base of the emargination sharply rounded; seventh ventral elongate, extending beyond the sixth by about one half the length of that segment, the sides straight and parallel, the apex truncate, feebly nicked at the middle. Lateral view; seventh ventral abruptly ascending from the apex of the sixth, apically truncate; last dorsals prolonged somewhat beyond the tip of the seventh ventral, the penultimate evenly rounded, the ultimate as a small triangular process.

Holotype, male, White Mountains, Arizona, June 23, 1947, C. P. Alexander, in the collection of the California Academy of Sciences.

At this locality, Dr. Alexander also collected a female of similar size and coloration. The pronotal disc has two large lateral pale spots, the elytra are short and do not have the apices tumid. For these reasons there is some question as to whether or not more than one species is represented. Until more material is available from this area, it is thought best to leave the female as doubtful and thus not designate it as a member of the type series.

Malthodes albimontanus new species

Plate V; figs. 71, 72

Black; the mandibles only pale; pubescence cinereous, sparse and inconspicuous. Length 2.5 to 2.75 mm.

Male: Head wider than the pronotum, finely sparsely granulate behind the eyes; eyes moderately prominent; antennae moderately stout, extending to the tips of the wings in repose, segments two and three equal, the fourth considerably longer, the intermediate segments about four and a half times as long as wide; pronotum transverse, the anterior angles rounded, the sides

sinuate, converging slightly to the hind angles which are prominent, all angles rather widely reflexed, disc finely granulose, shallowly excavated medially; elytra short, extending to slightly beyond the apex of the third abdominal segment, sparsely punctured basally, becoming finely rugose apically, the tips feebly tumid.

Female: Differs from the male in having large lateral pale spots on the pronotal disc; the pronotum a little more widely transverse, as wide as the head; antennae extending to the tips of the elytra, about three times as long as wide, the elytra extending only to the apex of the third ventral.

Male terminalia: Ventral view; sixth ventral narrow, the emargination completely dividing the visible portion of the segment, the base of the emargination angulate; seventh ventral elongate, stout, extending beyond the sixth by about one half the length of that segment, expanded medially, the sides arcuately rounded to the apex which is triangularly notched, the notch not quite as deep as wide, the tips moderately acute. Lateral view; seventh ventral suddenly bent up medially; last dorsals produced slightly beyond the seventh ventral, otherwise normal.

Holotype, male; *allotype,* female and eight *paratypes,* White Mountains, Arizona, June 22, 1947, C. P. Alexander; one *paratype,* one mile west of McNary, Apache County, Arizona, July 22, 1948, Floyd Werner; types in the collection of the California Academy of Sciences.

One of the females has the lateral pale spots of the pronotum so expanded as to leave only the anterior angles and a median discal spot dark. The wide median pronotal excavation is less evident on some specimens.

MALTHODES FRAGILIS (LeConte)

Plate V; figs. 73, 74

Malthinus fragilis LeConte, Proc. Acad. Nat. Sci. Phil. (2) 5, 1851, p. 346. *Malthodes fragilis* LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 61.

Piceous; head slightly darker, the basal two antennal segments, mandibles and apex of the clypeus pale; male seventh ventral testaceous with the apical notch infuscated; last abdominal segments of the female nigropiceous; pubescence cinereous, moderately conspicuous. Length 2 to 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured in front, becoming finely granulose on the neck; eyes moderately prominent; antennae moderately stout, extending to the tips of the wings in repose, segments two and three equal, the fourth evidently longer, the intermediate segments about three times as long as wide; pronotum moderately transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides straight, converging slightly to the hind angles which are prominent and rounded, marginal bead fine, the disc sparsely punctured, becoming finely granulate anteriorly; elytra extending to the apex of the fourth abdominal segment, finely sparsely punctured basally, becoming finely rugose apically.

Female: Similar to the male; head as wide as the pronotum, the eyes smaller and less prominent; antennae extending almost to the elytral tips, the

intermediate segments about twice as long as wide; elytra extending to the apex of the fifth abdominal segment.

Male terminalia: Ventral view; sixth ventral deeply emarginate, the base of the emargination angulately rounded, the tips acute angled; seventh ventral elongate, extending beyond the sixth by about one half the length of the sixth, the sides sinuately subparallel, narrowed at the basal third and the tips, the apex deeply triangularly notched, the tips acute. Lateral view; apices of the sixth ventral narrowed and produced, the tips rather sharply rounded; seventh ventral sinuate, the tips acute; penultimate dorsal slightly produced and apically truncate; ultimate dorsal not exposed.

LeConte recorded this species from Pennsylvania, Georgia, Virginia and California. Fall, on examining LeConte's California material, concluded that another species was represented. No specimens have been seen from west of the Mississippi River. Representatives of this species have been studied from: Michigan; Cliff. New Hampshire; Mt. Moose Lake. New Jersey; Wilmington. New York; Adirondack Lodge (Essex County), Heart Lake (Essex County), Mt. Marcy Trail (Uphill Brook), Mt. McIntyre, Olcott, Slide Mountain (Ulster County), Whitehill. Ontario; Kearney, Waubamic. Tennessee; Galtenberg (Great Smoky Mountain National Park). Vermont; Lake Willoughby.

LeConte (1851) described *Malthodes transversus* separating it from *M. fragilis* on the basis of the shape of the pronotum; *fragilis* having the pronotum transverse with the sides rounded and *transversus* having the pronotum quadrate with the sides straight and the angles prominent. In his later (1881) studies, LeConte saw fit to place his *M. transversus* as a synonym of *M. fragilis* to avoid confusion. Dr. H. C. Fall apparently considered that two species were represented or at least might be. Mr. C. A. Frost loaned the author a male that represented the *transversus* form, indicating that he thought it might be different. Considering these opinions, the apparent indecision of LeConte and the inaccessibility of the type to the author, *M. transversus* must be placed as a species indeterminata pending the study of some future student.

MALTHODES MITIFICUS Fall

Plate V; figs. 75, 76

Malthodes mitificus Fall, Ann. Ent. Soc. Am. 12, no. 1, 1919, p. 37.

Fuscotestaceous; head in front of the antennae, basal two thirds of the first antennal segment, pronotum, scutellum and the apices of the first five ventral abdominal segments yellow; apices of the elytra and apices and bases of the femora and tibiae slightly paler; pubescence cinereous. Length 3 to 3.5 mm.

Male: Head wider than the pronotum, finely sparsely punctured; eyes large and prominent, separated frontally by not more than their own horizontal diameter; antennae slender, extending almost to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum transverse, finely sparsely punctured, the sides straight, converging slightly from the narrowly reflexed,

rounded anterior angles to the basal angles which are narrowly prominent; elytra finely rugose to the tips which are tumid and finely punctured.

Female: Similar to the male; head not wider than the pronotum; antennae shorter, extending to about the tips of the elytra, the intermediate segments about three times as long as wide.

Male terminalia: Ventral view; sixth ventral narrowed apically, deeply emarginate, the base of the emargination rather sharply rounded; seventh ventral broad, extending beyond the sixth by about the length of that segment, gradually narrowing apically, the tip broadly shallowly notched. Lateral view; seventh ventral sinuate, the tip rounded; penultimate dorsal apically truncate; ultimate dorsal narrowly exposed, the apex similar to that of the penultimate.

Fall described this species from a series of five males collected at Mokelumne Hill, California by F. E. Blaisdell. A specimen of this series has been available for study. Additional material has been seen from Pasadena and Fallen Leaf Lake, Eldorado County, California and Hyde Park, Utah.

Malthodes knowltoni new species

Plate V; figs. 77, 78

Piceous; head slightly darker; pronotum fulvotestaceous with a large dark spot on each side just laterad of the middle; elytral apices testaceous; intermediate ventral abdominal segments testaceous at the middle, the apices of all ventral abdominal segments narrowly pale; pubescence cinereous, inconspicuous. Length 2 mm.

Male: Head conspicuously wider than the pronotum, finely sparsely punctured behind the antennae; eyes moderately large and prominent; antennae slender, extending well beyond the tips of the wings in repose, segments two to four progressively longer, the intermediate segments nearly five times as long as wide; pronotum transverse, the anterior angles evenly rounded and very narrowly reflexed, the sides sinuate, converging slightly to the hind angles which are prominent, marginal bead fine, disc finely sparsely punctured; elytra extending to the apex of the third ventral segment, sparsely punctured basally, becoming feebly rugose medially, the apices feebly tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral narrowed apically, narrowly deeply emarginate, the base of the emargination rounded; seventh ventral extending beyond the sixth by a little over one half the length of the sixth, the sides somewhat rounded to the apex which is widely shallowly emarginate. Lateral view; seventh ventral moderately stout, feebly sinuate, the tips rounded; last dorsals normal.

Holotype, male, Mt. Timpanogus, Utah, July 26, 1945, G. F. Knowlton, in the collection of the United States National Museum.

A specimen from Jemez Mountains, New Mexico, in a rather dilapidated condition appears to be this species. The pronotal spots are enlarged and

cover nearly the entire disc; the seventh ventral is more evidently sinuate but in a manner that indicates that it is distorted. The condition of this specimen permits only a tentative assignation to this species.

Malthodes chapini new species

Plate V; figs. 79, 80

Piceous; head in front of the eyes, the basal angles and a median transverse strip on the pronotum obscurely paler; intermediate abdominal segments pale; female fuscotestaceous, basal two antennal segments and legs paler, the pale pronotal strip wider and more pronounced; pubescence cinereous, moderately conspicuous. Length 3 to 3.5 mm.

Male: Head slightly wider than the pronotum, finely sparsely granulate behind the antennae; eyes moderately prominent; antennae moderately stout, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely rounded, the sides straight, converging slightly to the obtusely rounded hind angles, marginal bead fine, disc finely sparsely punctate, finely rather closely granulate near the hind angles, a narrow rather deep impression medially near the base; elytra finely sparsely punctured basally, becoming feebly rugose punctate apically.

Female: Similar to the male; head as wide as the pronotum; eye moderately prominent; antennae extending to the middle of the elytra, the intermediate segments about two and a half times as long as wide; granulations near the hind angles of the pronotum finer, the basal median impression less deep but evident.

Male terminalia: Ventral view; sixth ventral narrowed apically, deeply moderately widely emarginate, the base of the emargination angulate; seventh ventral short, moderately stout, the sides parallel to the apex which is truncate. Lateral view; seventh ventral feebly ascending, the dorsal surface curved apically to angulately meet the ventral surface; last dorsals normal.

Holotype, male; *allotype,* female and two *paratypes,* Fort Pendleton, West Virginia. July 8 to 10, Hubbard and Schwarz, in the collection of the United States National Museum.

Malthodes adoxus new species

Plate V; figs. 81, 82

Piceous; clypeus, mandibles, basal two segments of the antennae and basal and apical margins of the pronotum testaceous, obscurely so in the case of the antennal segments; apices of coxae, bases of the trochanters, apices of the hind tibiae and bases and apices of the tibiae of the front and middle legs narrowly pale; sides of the basal abdominal segments pale; pubescence cinereous, inconspicuous. Length 2.5 to 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes prominent; antennae moderately stout, becoming slender apically, extending to the tips of the wings in repose, the third segments nearly half again as long as the second and slightly longer than the fourth, the inter-

mediate segments fully five times as long as wide; pronotum moderately transverse, the anterior angles obliquely rounded, the sides sinuate and converging slightly to the hind angles which are rectangular, the anterior angles narrowly reflexed, marginal bead rather thick, the disc rather finely closely granulose; elytra finely sparsely punctured basally, becoming rugose punctate apically.

Female: Similar to the male; the head as wide as the pronotum; eyes not as prominent; antennae extending to the elytral apices, the intermediate segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral narrowed apically, the apex deeply rather narrowly emarginate, the base of the emargination angulate; seventh ventral elongate, stout, extending beyond the sixth by a little less than the length of the sixth, wide basally, narrowing to the apex which is truncate. Lateral view; seventh ventral straight, narrowing slightly to the apex which is subtruncately rounded; last dorsals slightly prolonged, otherwise normal.

Holotype, male; *allotype,* female and fifteen *paratypes,* Kelly Creek, Wapinitia, Oregon, June 22, 1947, K. M. Fender, types in the collection of the California Academy of Sciences.

Malthodes truncatus new species

Plate V; figs. 83, 84

Piceotestaceous; head brunneous, pale in front; pronotum flavous, the sides becoming brunneous; femora of the hind legs pale medially; all tarsi canescent; pubescence cinereous, inconspicuous. Length 1.5 mm.

Male: Head elongate, slightly wider than the pronotum, finely sparsely punctured behind the eyes; eyes moderately prominent; antennae submoniliform, stout, extending to the tips of the elytra, segments two to four equal, the intermediate segments a little over twice as long as wide; pronotum transverse, the anterior angles obliquely truncated, the sides straight, converging slightly to the hind angles which are prominent, the anterior angles widely reflexed, marginal bead moderately thick, disc strongly depressed medially, this depression transverse, finely sparsely punctured; elytra feebly rugose punctate for their entire length.

Female: Similar to the male; pronotum more evidently transverse, wider than the head, the disc more strongly impressed medially.

Male terminalia: Ventral view; sixth ventral narrowed apically, deeply moderately widely emarginate, the base of the emargination evenly rounded; seventh ventral stout, extending to the lateral tips of the sixth, apically truncate. Lateral view; seventh ventral arising on the plane of the suture of the sixth ventral and sixth dorsal, straight and subtruncately rounded apically.

Holotype, male and *allotype,* female, Salem, Utah, May 24, 1945, G. F. and M. W. Knowlton, in the collection of the United States National Museum.

Malthodes tribulus new species

Plate VI; figs. 85, 86

Piceotestaceous; the head slightly darker, front and mandibles pallescent; basal antennal segments obscurely paler basally, becoming piceous apically;

pronotum tending to become flavescent near the sides, the hind angles yellowish; intermediate abdominal segments pale medially, articulations of legs more or less widely pale; sixth ventral of male rufobrunneous, the seventh ventral testaceous; pubescence cinereous. Length 3 to 3.5 mm.

Male: Head wider than the pronotum, closely granulose and with small rugae behind the eyes; eyes large and prominent; antennae moderately stout, extending to a little beyond the tips of the elytra, segments two and three equal, the fourth slightly longer, the intermediate segments about three and a half times as long as wide; pronotum moderately transverse, the anterior angles widely deeply reflexed and obliquely rounded, the sides narrowly reflexed, feebly sinuately converging to the obtusely rounded hind angles which are widely shallowly reflexed, disc finely rather closely granulate, a pair of low elongate tumidities arise at the base and near the middle, directed diagonally towards the anterior angles, a similar pair of low tumidities arise just anterior to and parallel to these; elytra granulose basally, becoming rugose apically, the tips smooth and feebly tumid.

Female: Similar to the male, slightly darker throughout; head as wide as the pronotum; eyes smaller and less prominent; intermediate antennal segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral widely impressed medially, narrowly deeply emarginate, the base of the emargination sharply rounded; seventh ventral elongate, extending slightly beyond the tips of the sixth, moderately stout basally, widening to the apex which is shallowly bisinuately emarginate giving the segment the appearance of having three short apical teeth. Lateral view; sixth ventral elongate, concealing most of the seventh; apical exposed portion of the seventh ventral stout, diagonally truncate, the truncation shallowly incised; last dorsals somewhat prolonged and narrowed, otherwise normal.

Holotype, male; *allotype*, female and nine *paratypes*, Langdale, Chambers County, Alabama, collected by M. H. Smith, in the collection of the United States National Museum.

Malthodes atrocoeruleus new species

Plate VI; figs. 87, 88

Atrocoeruleus to feebly aeneous; clypeus and mandibles obscurely paler, the basal two antennal segments pale beneath; pronotum flavous, the apical and basal margins widely darker; pubescence cinereous. Length 2.25 to 2.5 mm.

Male: Head wider than the pronotum, finely closely granulate behind the antennae; eyes moderately prominent; antennae stout, second segment about two thirds the length of the third and a little more than half the length of the fourth, the intermediate segments about three and a half times as long as wide; pronotum moderately transverse, the anterior angles widely obliquely truncated, the sides rather strongly sinuate, converging slightly to the hind angles which are obtusely rounded, the sides narrowly reflexed, more widely

so anteriorly, marginal bead thick, disc rather finely closely granulate; elytra short, attaining the base of the fourth abdominal segment, sparsely punctured, basally, becoming feebly rugose medially.

Female: Similar to the male; head and pronotum more closely granulate, intermediate antennal segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral deeply moderately widely emarginate, the base of the emargination rounded; seventh ventral elongate, stout, extending beyond the sixth by about the length of that segment, the sides divergent to the apex which is sharply broadly truncate. Lateral view; seventh ventral stout, evenly ascending apically, the tip truncate; sides of the penultimate dorsal arcuate, ascending apically to the dorsal surface; ultimate dorsal narrow, inflexed against the penultimate, the apical third bent rectangularly to the base of the segment, the apex truncate.

Holotype, male; *allotype,* female and five *paratypes,* labeled "Tex." from the Leng collection, the Cantharidae of which were purchased by the author, types in the collection of the United States National Museum.

GROUP II

1. Size smaller, about one millimeter in length ..... *parvulus*
   Size larger, two to three millimeters in length 2
2. Ventral accessory process one half or less the length of the seventh ventral .... *alexanderi*
   Ventral accessory process nearly as long as or longer than the seventh ventral 3
3. Seventh ventral apically clavate, ventral accessory process broader than the seventh ventral ..... *exilis*
   Seventh ventral parallel sided to the middle then evenly narrowed to the apex; ventral accessory process filamentous, the tip bent ..... *whittakeri*

MALTHODES PARVULUS (LeConte)

Plate VI; figs. 89, 90

Malthinus parvulus LeConte, Proc. Acad. Nat. Sci. Phila. (2) 5, 1851, p. 346. *Malthodes parvulus* LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 63.

Canescent; the head piceous, the antennae beyond the third segment becoming piceous, the apical abdominal segments piceous; pubescence cinereous, inconspicuous. Size minute, length 1 to 1.5 mm.

Male: Head narrower than the pronotum, finely punctulate behind; eyes moderately prominent; antennae stout, submoniliform, extending to about the apical third of the elytra, the second segment longer than the third and first which are equal, the intermediate segments about twice as long as wide; pronotum widely transverse, the anterior angles obliquely rounded, the sides faintly sinuate, rather strongly convergent to the hind angles which are obtusely rounded, the sides rather strongly reflexed, the marginal bead rather thick, the disc sparsely punctured; elytra finely rugose punctate.

Female: Similar to the male; pronotum a little less transverse, the sides arcuately rounded to the obtusely rounded hind angles; antennae extending to the middle of the elytra, the intermediate segments about one and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral broadly emarginate, the

emargination reaching to about the basal half of the segment and evenly rounded; seventh ventral elongate, extending beyond the sixth by a little less than the length of that segment, wide basally, narrowing rapidly to the tip which is sharply rounded. Lateral view; seventh ventral stout, straight, the tip rounded; last dorsals prolonged slightly beyond the seventh ventral, the tip beveled dorsally.

LeConte knew this species from Lake Superior and Massachusetts. Specimens have been examined from the following localities: Connecticut; Cornwall. District of Columbia; Washington. Lake Superior; Eagle Harbor. Maine; Monroe, Hartland and Pittston. Maryland; Priest Bridge. Massachusetts; Sherborn and Tyngsboro. Michigan; Detroit and Marquette. New Hampshire; Antrim. New York; Top Mountain and McIntyre. Ohio; Scioto County. Virginia; Vienna. West Virginia; Fort Pendleton.

MALTHODES ALEXANDERI Fender

Plate VI; figs. 91, 92

Malthodes alexanderi Fender, Pan-Pac. Ent. 25, no. 4, 1949, p. 189.

Nigropiceous; antennae black, the mandibles, pronotal margin, bases of trochanters, apices of coxae, seventh ventral and apex of the last dorsal pale; pubescence cinereous. Length 3 to 3.5 mm.

Male: Head wider than the pronotum, finely granulose behind the eyes which are prominent; antennae slender, extending to the tips of the wings in repose, segments two to four increasing in length, the intermediate segments about five times as long as wide; pronotum transverse, the anterior angles rounded and narrowly reflexed, the sides slightly concave, converging to the hind angles which are sharply rounded, marginal bead fine, the disc finely sparsely punctured; elytra extending to the apex of the fifth abdominal segment, finely sparsely punctured basally, becoming slightly rugose apically.

Female: Similar to the male; head subequal to the pronotum, the eyes smaller and less prominent; antennae extending to about the tips of the elytra, the intermediate segments about four times as long as wide.

Male terminalia: Last dorsal somewhat produced, the apex shallowly arcuately emarginate; sixth ventral broadly deeply emarginate, the base of the emargination evenly rounded; seventh ventral elongate, widest at the base, narrowing rather rapidly to the basal two fifths then less rapidly so to the tip which is sharply rounded; seventh ventral in profile obliquely ascending from the basal two fifths; just above the seventh ventral an obliquely ascending spatulate process which in profile appears triangularly clavate; a shorter spatulate process with the sides rather strongly deflexed arises just below the last dorsal.

This species was described from a lone male collected on Wonderland Trail, Mt. Rainier, Washington by C. P. Alexander. For the neallotype, a female, collected at Many Glaciers National Park, Montana, July 6, 1949, C. P. Alexander, has been selected. Additional specimens have been studied from: British Columbia; Ainsworth, Fernie, Lorna and Midday Valley. Ore-

gon; North Fork of Iron Creek (Mount Hood) and Salmon River (Mt. Hood).

MALTHODES EXILIS (Melsheimer)

Plate VI; figs. 93, 94

Malthinus exilis Melsheimer, Proc. Acad. Nat. Sci. Phila. 2, 1846, p. 305. *Malthinus exilis* LeConte, Proc. Acad. Nat. Sci. 5, 1851, p. 346. Not *Malthodes* exilis LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 61.

Piceous to brunneous; apex of the clypeus and the mandibles obscurely pale; legs testaceous, sometimes with the femora darker medially; pubescence cinereous, short and inconspicuous. Length 2.5 to 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured, becoming finely scabrose back of the eyes and on the neck, a finely impressed longitudinal line extending from between the bases of the antennae to the neck; eyes large and prominent; antennae stout, extending to about half way between the apices of the elytra and the tips of the wings in repose, segments two to four equal, the intermediate segments about three times as long as wide; pronotum transverse, the anterior margin widely shallowly emarginate at the middle, the anterior angles rounded, the sides strongly sinuate, converging slightly to the hind angles which are prominent, marginal bead thick, disc finely sparsely punctured, two tubercles are approximate and slightly in front of the middle, a broad U shaped ridge with the base of the U overlapping the posterior margin and the sides extending nearly to and just laterad of the tubercles; elytra short, apically dehiscent, extending to the base of the second abdominal segment, finely rugose punctate, more closely so apically.

Female: Similar to the male; antennae extending to the apices of the elytra, the intermediate segments about one and a half times as long as wide; elytra barely attaining the basal abdominal segment.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination rounded; seventh ventral elongate, clavate, extending beyond the sixth by about a third the length of the sixth; ventral accessory process wider and slightly longer than the seventh ventral, the sides bisinuately parallel, the tip truncate; last dorsals broadly produced, not narrowed apically, laterally arched forming a canopy over the ventrals. Lateral view; seventh ventral slender, feebly sinuate; ventral accessory process stouter than the seventh ventral, apically truncate.

LeConte records this species from Pennsylvania and Maryland, however it is quite apparent that he had some other species in mind. Of *exilis* he says: "Very similar to *fragilis* but the prothorax, front legs and base of the antennae are yellow, male last ventral is narrower, prolonged, channeled and acutely emarginate at tip." Mr. Werner's sketch of the terminalia of the only male in the Melsheimer series shows that LeConte had misinterpreted Melsheimer's species. The pronotal coloration is entirely different and the seventh ventral is not acutely emarginate at the tip. Just what species LeConte had in mind, I have been unable to determine.

The female of *exilis* is one of the few that can be recognized when taken

not in company with the male. It has the same pronotal conformation that appears to be confined to this species.

Malthodes whittakeri new species

Piceous; the mandibles, apex of the clypeus, basal two segments of the antennae, pronotal margins, apices and bases of all femora and tibiae obscurely paler; pubescence cinereous, sparse. Length 2 to 2.5 mm.

Male: Head wider than the pronotum, finely sparsely punctured; eyes large and prominent; antennae stout, extending to the tips of the wings in repose, segments two and three equal, the fourth slightly longer, the intermediate segments about three times as long as wide; pronotum moderately transverse, the anterior angles rounded and narrowly reflexed, the sides arcuate to the hind angles which are prominent, marginal bead fine, disc finely sparsely punctate medially, becoming somewhat granulose towards the sides; elytra sparsely punctate throughout with faint indications of rugae apically.

Female: Similar to the male but with the pale markings more evident; the eyes small; the head as wide as the pronotum; antennae extending to the elytral apices, the intermediate segments about twice as long as wide.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination sharply rounded; seventh ventral elongate, narrow, extending beyond the sixth by about one and a half times the length of the sixth, the sides parallel to the basal half then narrowed to the tip which is acutely rounded; penultimate dorsal prolonged, the sides straight, converging slightly to the apex which is emarginate. Lateral view; seventh ventral bent at the basal third, the apical two thirds straight and horizontal, the tip rounded; penultimate dorsal elongate, the apex sharply beveled above; a fine threadlike accessory process arising just above the seventh ventral, slightly longer than that segment, straight almost to the tip where it is curved, this filament may be found in almost any of the positions that a loose pliable basal connection will permit.

Holotype, male, Gatlinburg, Great Smoky Mountain National Park, Tennessee, mixed mesophyl, 1500 feet, July 5, 1947, R. H. Whittaker: *Allotype,* female, same locality as the type, oak-hickory, 1500 feet, June 26, 1947, R. H. Whittaker. The following *paratypes* from the same locality, collected by R. H. Whittaker: 1, mixed mesophyl, 1500 feet, June 28, 1947; 1, same data as allotype; 2, pine-oak, 1500 feet, June 17, 1947; 4, cove forest, July 20, 1947, 3000 feet. One paratype, Highlands, North Carolina, June 1888, Blanchard.

GROUP III

1. In profile, seventh ventral straight, the tip beveled beneath ..... *werneri*
   In profile, seventh ventral ascending apically, the tip not beveled beneath ..... *curvatus*

Malthodes werneri new species

Plate VI; figs. 97, 98

Piceotestaceous; head darker, the mandibles and apex of the clypeus pale; pronotum with a large median dark spot the edges of which are diffuse; basal abdominal segments flavous; pubescence cinereous, fine and inconspicuous. Length 2.5 mm.

Male: Head wider than the pronotum, finely sparsely punctate behind the antennae; eyes large and prominent; antennae moderately stout, segments two and three equal, the fourth longer, the intermediate segments about three and a half times as long as wide; pronotum moderately transverse, the anterior angles rounded, sides sinuate to the hind angles which are prominently rounded, all angles rather widely reflexed, marginal bead thick, disc finely closely granulose varying to virtually smooth and impunctate; elytra finely rugose punctate, the apices narrowly tumid.

Female: Similar to the male; pronotal dark spot considerably restricted; eyes smaller and less prominent; sides of the pronotum feebly sinuate; intermediate antennal segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination evenly rounded; seventh ventral stout, elongate, extending beyond the sixth by about one and a third times the length of the sixth, the apex widely triangularly notched, the tips acute. Lateral view; sixth ventral small, seventh ventral strongly channeled, straight, stout, the apex strongly beveled beneath; last dorsals slightly prolonged, extending nearly to the tip of the seventh ventral; ultimate dorsal triangular, descending apically.

Holotype, male, Marion, Massachusetts, July 7, 1903, Bowditch Coll.; *Allotype,* female and one *paratype,* Beltsville, Maryland, June 4, 1914; *Paratypes:* 16, Oakland, Maryland, July 9 to 12, Hubbard and Schwarz; 1, Bladensburg, Maryland, June 22, Hubbard and Schwarz; 4, Fort Pendleton, West Virginia, July 7 to 10, Hubbard & Schwarz; 1, Washington, District of Columbia, June 30, Hubbard and Schwarz. Types in the collection of the Museum of Comparative Zoology.

There is considerable variation in the coloration of this species. In the series from Oakland, Maryland, the pronotal color varies from flavous to almost entirely piceous. The specimens from Fort Pendleton, West Virginia, have the basal two segments of the antennae yellowish.

MALTHODES CURVATUS LeConte

Plate VI; figs. 99, 100

Malthodes curvatus LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 61.

Piceous to piceotestaceous; pronotum rufotestaceous; the head in front of the eyes and basal two antennal segments yellowish; front and middle legs and the femora and bases of the tibiae of the hind legs yellowish; sides and apices of the ventral abdominal segments rather widely pale; pubescence cinereous, fine, short and sparse. Length 3 to 2.5 mm.

Male: Head evidently wider than the pronotum, finely rather closely granulate behind the antennae; eyes rather large and prominent; antennae moderately stout, extending to a little beyond the tips of the elytra, segments two and three equal, the fourth slightly longer, the intermediate segments about three and a half times as long as wide; pronotum transverse, the anterior angles obliquely truncated and moderately widely reflexed, the sides converging to the hind angles which are obtuse, marginal bead fine anteriorly becoming thick at the sides and base, disc very finely punctured; elytra extending to the apex of the fifth abdominal segment, finely rugose punctate to the tips which are tumid and finely punctured.

Female: Similar to the male; head as wide as the pronotum; eyes smaller and less prominent; antennae extending to about the middle of the elytra, the intermediate segments about two and a half times as long as wide; sides of the pronotum sinuate, the hind angles prominent.

Male terminalia: Ventral view; sixth ventral slightly expanded apically, moderately widely deeply emarginate, the base of the emargination subtruncately rounded; seventh ventral stout, elongate, extending beyond the sixth by about twice the length of that segment, slightly narrowed basally and apically, the apex deeply acutely notched, the notch about a third again as deep as the segment is wide at the apex, the tips acute. Lateral view; seventh ventral stout, deeply channeled throughout its length, up-curved beyond the middle, the tip acute; last dorsals slightly prolonged, otherwise normal; a straight spiniform accessory process arising slightly above the seventh ventral; slightly above the first accessory process a similar process but slightly arcuately curved up; virtually resting on the latter process a stout strongly ascending process that is narrowly cleft apically.

LeConte's type was collected in Illinois. Three specimens have been studied that were collected in Livingston, Pennsylvania.

GROUP IV.

1. Seventh ventral extending beyond the sixth by nearly twice the length of the sixth .. 2
   Seventh ventral extending beyond the sixth by less than the length of the sixth or not at all 4
2. Seventh ventral forked to basal third ..... *flexuosus*
   Seventh ventral forked to about the middle 3
3. Seventh ventral parallel sided from the base to near the furcation ..... *hatcheana*
   Seventh ventral narrowed from the base to the furcation ..... *vapidus*
4. Seventh ventral terete, not extending beyond the tips of the sixth ..... *greeni*
   Seventh ventral somewhat flaccid, extending beyond the sixth by about one fourth the length of the sixth ..... *knulli*

Malthodes flexuosus new species

Plate VI; figs. 101, 102

Piceous; mandibles and apex of the clypeus obscurely paler; pronotal disc with large obscurely pale lateral spots; apices of the coxae and basal halves of the trochanters of the middle and hind legs pale; pubescence cinereous, sparse and inconspicuous. Length 3.25 to 4 mm.

Male: Head much wider than the pronotum, finely granulate behind the eyes which are large and prominent; antennae slender, extending to the tips of the wings in repose, segments two to four progressively longer; the intermediate segments about five times as long as wide; pronotum moderately transverse, the anterior angles prominent and rather widely reflexed, evenly rounded, the sides deeply concave, converging slightly to the hind angles which are prominently rounded, marginal bead fine, disc finely rather sparsely punctured; elytra rugose punctate throughout.

Female: Similar to the male; head very slightly wider than the pronotum,

the eyes less prominent; antennae extending to the elytral apices, the intermediate segments about four times as long as wide; pronotum dark flavous with the margins diffusely darker, the anterior angles rounded but not prominent, the sides sinuate to the prominent hind angles.

Male terminalia: Ventral view; sixth ventral narrowed apically, the apex broadly deeply subtriangularly emarginate, the base of the emargination sharply rounded; seventh ventral elongate, extending beyond the sixth by twice the length of the sixth, stout basally, narrowing rather sharply to about the middle where it is forked, the forks arcuate making the incision oblong-ovate in outline. Lateral view; seventh ventral sinuate, the dorsal and ventral surfaces parallel to the apex which is rounded; last dorsals normal.

Holotype, male; *allotype,* female and fifteen *paratypes,* Kelly Creek, Wapinitia, Oregon, June 22, 1947, K. M. Fender. *Paratypes:* 4, Salmon River, Mount Hood, Oregon, July 30, 1948, K. M. Fender; 2, Still Creek Forest Comp, Mount Hood, Oregon, July 31, 1948, K. M. Fender. Types in the collection of the California Academy of Sciences.

Malthodes hatcheana new species

Plate VII; figs. 103, 104

Black; mandibles and bases of the trochanters pale elytral apices obscurely paler; pubescence cinereous, fine and sparse. Length 3 mm.

Male: Head evidently wider than the pronotum, finely sparsely punctured; eyes moderately large and prominent; antennae moderately slender, extending to the tips of the wings in repose, segments two and three equal, the fourth longer, the intermediate segments almost four and a half times as long as wide; pronotum transverse, the anterior angles obliquely rounded, the sides sinuate, converging slightly to the hind angles which are obtusely rounded, marginal bead fine, the disc very finely sparsely punctured; elytra long, extending to the apex of the sixth abdominal segments, sparsely punctured basally, becoming feebly rugose towards the tips, the apices feebly tumid and finely punctured.

Female: Head narrower than the pronotum; antennae extending to about the elytral tips, the intermediate segments about two and a half times as long as wide; elytra short, extending to about the middle of the third abdominal segment.

Male terminalia: Ventral view; sixth ventral apically narrowed, the apex broadly moderately deeply emarginate, the base of the emargination rounded; seventh ventral elongate, extending beyond the sixth by about twice the length of the sixth and fully four times as long as wide at its widest portion, moderately narrow basally, narrowing to the middle where it is forked, the base of the furcation acute, the forks slightly incurved apically. Lateral view; seventh ventral evenly up curved just before the furcation, the forks straight and slightly swollen; last dorsals prolonged; the penultimate dorsal normal; ultimate dorsal produced downward and narrowed apically.

Holotype, male, Bellview, Oregon, June 10, 1948, K. M. Fender. *Allotype,* female, Hendersons Bridge, Amity, Oregon, June 16, 1948, K. M. Fender. Two *paratypes,* Bellview, Oregon, June 23 & 26, 1949, K. M. Fender. Types in the collection of the California Academy of Sciences.

MALTHODES VAPIDUS Fall

Plate VII; figs. 105, 106

Malthodes vapidus Fall, Ann. Ent. Soc. Am. 12, 1919, p. 41.

Fuscotestaceous; head piceous, becoming paler in front of the antennae; pronotum, becoming yellowish along the basal margin near and at the hind angles, the anterior angles narrowly infuscate; elytral apices yellowish; sides and apical margins of the ventral abdominal segments rather widely pale; pubescence cinereous and inconspicuous. Length 2.5 to 3.5 mm.

Male: Head about one fourth wider than the pronotum, finely sparsely granulose behind the antennae; eyes large and prominent; antennae slender, extending beyond the tips of the wings in repose, segments two to four increasing in length, the intermediate segments about four and a half times as long as wide; pronotum moderately transverse, the anterior angles rounded and feebly reflexed, the sides straight, converging slightly to the hind angles which are prominent and rounded, marginal bead fine, the disc finely sparsely punctured; elytra sparsely punctured basally, becoming rugose medially, the tips tumid and finely punctured.

Female: Similar to the male but the head not wider than the pronotum; eyes much smaller; antennae extending to slightly beyond the middle of the elytra with the intermediate segments about twice as long as wide; pronotal hind angles not prominent.

Male terminalia: Ventral view; sixth ventral moderately subtriangularly emarginate, the base of the emargination angulately rounded; seventh ventral elongate, about two and a half times as long as wide at the widest portion, extending beyond the sixth by a little over one and a half times the length of the sixth, wide basally, narrowing slightly to the middle where it is forked, the base of the furcation rounded, the forks straight and slightly divergent. Lateral view; seventh ventral sinuate, parallel sided, the apex rounded; last dorsal moderately prolonged; sides of the apical half of the penultimate dorsal straight diagonally ascending apically; ultimate dorsal normal, pentagonally produced.

This species was described from a series collected at Lake Tahoe, California. Specimens have been studied from Fallen Leaf Lake (Eldorado County) and Tallac, California.

MALTHODES GREENI Fender

Plate VII; figs. 107, 108

Malthodes greeni Fender, Pan-Pac. Ent. 25, no. 4, 1949, pp. 187-189.

Head dark brown with the clypeus and mandibles yellow, the antennae piceous with the basal two segments pale; pronotum dark reddish brown, obscurely paler near the angles; scutellum and elytra piceous; thorax yellow beneath, the body beneath testaceous; coxae, trochanters, apices and bases of the femora and tibiae and bases of the first tarsal segments pale; sides of the basal five abdominal segments widely paler, the apex of the seventh ventral pale; pubescence cinereous. Length 2.5 to 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes large and prominent; antennae stout, extending beyond the apices of the elytra, second and third segments equal, the fourth longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely truncated, the sides straight and parallel to the hind angles which are obtusely rounded, marginal bead fine, disc finely sparsely punctured; elytra extending to the base of the fifth abdominal segment, finely sparsely punctured basally, becoming feebly rugose medially, the apices tumid and finely punctured.

Female: Differs from the male in having the eyes smaller, the antennae shorter with the intermediate segments about two and a half times as long as wide, the last abdominal segment being blackish brown.

Male terminalia: Ventral view; sixth ventral feebly narrowed apically, widely very deeply emarginate, the base of the emargination evenly rounded; seventh ventral widely forked nearly to the base of the visible portion of the segment, terete, the apices not extending as far as the tips of the sixth. Lateral view; sixth ventral somewhat prolonged, subovate; seventh ventral slender feebly ascending apically; penultimate dorsal slightly prolonged, apically truncate, concealing the ultimate dorsal.

Known only from the type series which was collected at Lucedale, Mississippi by H. Dietrich.

Malthodes knulli new species

Plate VII; figs. 109, 110

Piceous; head black with the mandibles obscurely paler; trochanters, basal abdominal segments laterally, the intermediate segments, the sixth medially and the seventh basally testaecous; pubescence cinereous. Length 2.5 to 3 mm.

Male: Head wider than the pronotum, finely granulate behind the antennae; eyes moderately small and prominent; antennae stout, extending to the apices of the elytra, segments two and three equal, the fourth longer, the intermediate segments two and a half times as long as wide; pronotum transverse, the anterior angles obliquely rounded, the sides sinuate, converging slightly to the hind angles which are feebly prominent, the anterior angles somewhat reflexed, marginal bead fine, the disc finely punctured with a finely impressed median line extending from the base to the apical fourth, this line tending to expand laterally as it approaches the apex, elytra finely punctured basally with rather faint rugae apically.

Female: Similar to the male; head smaller, about as wide as the pronotum; antennae shorter, the intermediate segments about twice as long as wide; intermediate abdominal segments paler, the last ventral unusually long and deeply incised.

Male terminalia: Ventral view; sixth ventral greatly elongate, fully one and a half times as long as wide at its widest portion, very deeply emarginate, the base of the emargination acute; seventh ventral elongate, forked for almost its entire length, the base of the furcation narrowly rounded, the forks arcu-

ately separated and curved to the tips where they nearly meet. Lateral view; side pieces of sixth ventral elongate, subconical; seventh ventral arcuately ascending apically; penultimate dorsal elongate, the apex shallowly emarginate, not extending as far as the sides of the sixth ventral; ultimate dorsal concealed.

Holotype, male; *allotype*, female and three *paratypes*, Scioto County, Ohio, June 17, 1944, D. J. & J. N. Knull; two *paratypes*, same data as types but collected June 10, 1944.

GROUP V

1. Seventh ventral evenly sinuate in profile, apex notched both vertically and horizontally ..... *mediocciden*s
   Seventh ventral not evenly sinuate, apex not horizontally incised 2
2. Seventh ventral apically notched or forked 3
   Seventh ventral apically truncate ..... *longipennis*
3. Seventh ventral feebly ascending from the middle, apically notched 4
   Seventh ventral forked 5
4. Seventh ventral triangularly notched, tips acute, pronotum nigropiceous, the margins narrowly pale ..... *leachi*
   Seventh ventral narrowly notched, the tips not acute, pronotum rufotestaceous, sometimes with a diffusely darker median spot ..... *mollis*
5. Forks of seventh ventral divergent, base of emargination of sixth ventral rounded ..... *appendiculatus*
   Forks of seventh ventral parallel apically, base of emargination of sixth ventral truncate ..... *tularensis*

Malthodes medioccidens new species

Plate VII; figs. 111, 112

Piceous to piceotestaceous; head black, the mandibles and basal two antennal segments pale; pronotum flavous with a brunneous mottling to clear flavous; apices of the basal abdominal segments pale, more widely so towards the sides, seventh ventral of male pale; pubescence cinereous, moderately conspicuous. Length 2 to 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes large and prominent, the facets unusually coarse; antennae stout, extending to the tips of the wings in repose, the second and third segments equal, the fourth slightly longer, the intermediate segments about four and a half times as long as wide; pronotum rather strongly transverse, the anterior angles obliquely rounded, the sides feebly sinuately converging to the hind angles which are prominent, rather widely reflexed near the anterior angles, less strongly so at the hind angles, marginal bead moderately thick, disc finely sparsely punctured; elytra finely punctured basally becoming rugose punctate apically.

Female: Similar to the male; antennae shorter, extending to about the tips of the elytra; eyes smaller and less prominent; anterior angles of the pronotum evenly rounded, the sides less strongly sinuate and slightly convergent to the acutely prominent hind angles.

Male terminalia: Ventral view; apex of the sixth ventral very widely deeply emarginate, the emargination evenly rounded, the sides of the segment

acute apically; seventh ventral elongate, narrowed medially, the apex wider than the base and widely triangularly notched, the tips acute. Lateral view; sixth ventral produced at the sides, the apices acute; seventh ventral rather strongly sinuate, apically expanded, the apex notched, the base of this notch near the dorsal surface of the segment; penultimate dorsal slightly produced, not attaining the tips of the sixth; ultimate dorsal concealed as are any accessory processes.

Holotype, male, Utica, Illinois, May 15, 1946, F. G. Werner; *allotype*, female, Illinois, from the Blanchard collection. *Paratypes:* 3, Allegheny, Pennsylvania, May 19, 1889; 2, same locality, May 3, 1889; 5, White Heath, Illinois, J. C. Dirks; 2, Ontario: 1, Athens, Ohio, May 28, 1931, W. C. Stehr; 1, Waterloo Township, Athens County, Ohio, June 20, 1935, W. C. Stehr; 2, Buffalo, New York, June 1886, E. P. VanDuzee; 15, Illinois, Blanchard collection; 42, Delaware County, Ohio, May 5 to July 2, D. J. & J. N. Knull; 1, Columbus, Ohio, June 29, 1942; 1, Carbondale, Illinois, May 8, 1925, T. Frison; 1, Oakwood, Illinois, May 24, 1926, Frison & Auden. Types in the collection of the Museum of Comparative Zoology.

This species has been erroneously assigned a number of names. Allegheny specimens had been determined as *M. juliginosus* and *M. concavus;* those from White Heath, Illinois as *M. spado* and Blanchard specimens from Illinois as *M. exilis*. The author, through a misconception of *M. exilis* had assigned that name to this species. Mr. Werner's careful study of the type of *M. exilis* proved the inaccuracy of this conception.

*Malthodes mediocciden*s and *Malthodes frisoni* are the only two known species that have the male seventh ventral notched both vertically and laterally. The sixth ventral of *M. mediocciden*s does not envelop the dorsals in the manner of *M. frisoni*.

MALTHODES LONGIPENNIS Fall

Plate VII; figs. 113, 114

Malthodes mollis var. *longipennis* Fall, Ann. Ent. Soc. Am. 12, 1919, p. 38.

Fuscotestaceous; head piceous, becoming pale in front of the antennae, basal two segments of the antennae paler; pronotum rufotestaceous, a median dark spot with the edges diffuse; trochanters, apices of the coxae and bases of the tibiae narrowly pale; seventh ventral and apical emargination of the sixth testaceous; pubescence cinereous, fine and sparse. Length 3 mm.

Male: Head slightly wider than the pronotum, finely sparsely punctured behind the antennae; eyes moderately large and prominent; antennae moderately stout, extending to about the middle of the exposed portion of the wings in repose, segments two and three equal, the fourth slightly longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles rounded and narrowly reflexed, the sides straight, converging slightly to the hind angles which are obtusely rounded and narrowly reflexed, marginal bead fine, disc finely sparsely punctured; elytra extending to the base of the sixth abdominal segment, finely sparsely punctured basally, becoming strongly rugose punctate medially, the tips narrowly tumid and finely punctured.

Female: Unrecognized in material at hand.

Male terminalia: Ventral view; sixth ventral deeply moderately widely emarginate, the base of the emargination narrow and truncate, the sides of the emargination sinuate; seventh ventral elongate, extending beyond the sixth by about the length of that segment, stout basally, narrowing to the apex which is slightly expanded and truncate. Lateral view; seventh ventral parallel sided to near the apex where it is faintly dilated, the apex sharply beveled beneath, so much so as to make the apex virtually truncate; last dorsals not prolonged; a short apically ascending ventral accessory process.

Fall described this species as a variety of *M. mollis* from a pair collected at Eureka, California. Two males have been studied from Crescent City, California. The apically truncate seventh ventral and the curved ventral accessory process of this species should be considered specific differences from those of *M. mollis* in which the apex of the seventh ventral is triangularly notched and the ventral accessory process is straight.

Malthodes leechi new species
Plate VII; figs. 115, 116

Nigropiceous; the head black with the front and mandibles pale; pronotal margin narrowly pale, more widely so basally; apices of the fifth and sixth ventral abdominal segments testaceous; male terminalia, except for the tips of the seventh ventral, testaceous; pubescence cinereous with an aureous tinge, fine and sparse. Length 3.5 mm.

Male: Head slightly wider than the pronotum, very finely sparsely punctured; eyes small, less prominent than usual; antennae slender, extending to the tip of the abdomen, segments two and three equal, the fourth visibly longer, the intermediate segments about three and a half times as long as wide; pronotum moderately transverse, the anterior angles obliquely rounded and narrowly reflexed, the sides straight, converging to the hind angles which are prominent, marginal bead fine, the disc finely sparsely punctured; elytra moderately short, extending to about the middle of the fourth abdominal segment, finely punctured basally becoming rugose apically.

Female: Similar to the male; the antennae extending to the elytral apices, the intermediate segments about two and a half times as long as wide.

Male terminalia: Ventral view; fifth ventral bisinuate apically; sixth ventral widely deeply emarginate, the base of the emargination rounded, covered slightly by a short median prolongation of the fifth; seventh ventral stout, elongate, the sides concavely narrowing slightly to about the apical third then parallel to the apex which is triangularly incised, the tips acute; apex of the penultimate dorsal shallowly emarginate. Lateral view; seventh ventral slightly up curved just before the middle, the apex beveled beneath; ventral accessory process prolonged, knobbed at the tip; last dorsals slightly prolonged, the penultimate widely shallowly emarginate apically.

Holotype, male; and *allotype,* female, Pygmy Forest, Fort Bragg, Mendocino County, California, June 14, 1948, collected by H. B. Leech, in the collection of the California Academy of Sciences.

MALTHODES MOLLIS Fall

Plate VIII; figs. 117, 118

Malthodes mollis Fall, Ann. Ent. Soc. Am. 12, 1919, pp. 37-38.

Fuscotestaceous; head blackish becoming testaceous in front of the antennae; pronotum rufotestaceous frequently with a diffuse median darker area; apices of the coxae, trochanters and bases of the tibiae diffusely paler; seventh ventral and the apical emargination of the sixth of the male testaceous; pubescence cinereous, suberect and sparse. Length 2.5 to 3 mm.

Male: Head slightly wider than the pronotum, finely very sparsely punctured behind the antennae; eyes moderately prominent; antennae moderately stout, extending to about the tips of the elytra, segments two and three equal, the fourth slightly longer, the intermediate segments about three and a half times as long as wide; pronotum moderately transverse, the narrowly reflexed anterior angles rounded, the sides straight, converging slightly to the rounded hind angles which are narrowly reflexed, marginal bead fine, the disc finely sparsely punctured; elytra extending to the apex of the penultimate dorsal, confusedly punctured basally, becoming rather strongly rugose apically, the tips narrowly tumid and finely punctured.

Female: Similar to the male but the head as wide as the pronotum; antennae extending to the apical fourth of the elytra, the intermediate segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral deeply emarginate, the base of the emargination sharply rounded; seventh ventral elongate, extending beyond the sixth by about one and a half times the length of that segment, stout basally, narrowing to the apex which is triangularly notched at the middle. Lateral view; seventh ventral feebly ascending, the tip beveled beneath; last dorsals not appreciably prolonged, the penultimate dorsal arcuate apically, the ultimate not exposed; ventral accessory process straight, moderately stout and apically subclavate.

Fall described this species from Marin County, Muir Woods and Lagunitas in California. Specimens have been studied from the following California localities: Eureka, Marin County (paratypes), Yorkville, Mendocino County, Alameda County, Humboldt County, mountains back of Alma, Berkeley, Cazadero, Ross (Marin County), Fairfax, Muir Woods (paratypes).

MALTHODES APPENDICULATUS Fall

Plate VIII; figs. 119, 120

Malthodes appendiculatus Fall, Ann. Ent. Soc. Am. 12, 1919, pp. 38-39.

Piceous to fuscous; head black behind, flavous in front of the antennae, the basal antennal segments pale; pronotum yellow; apices of the fifth and sixth ventral abdominal segments of the male pale medially, the seventh and the accessory process pale; pubescence cinereous. Length 3.5 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind

the antennae; eyes rather large and prominent; antennae moderately stout, extending to the tips of the wings in repose, segments two and three equal, the fourth evidently longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely truncated, the sides feebly arcuately converging to the hind angles which are obtusely rounded, marginal bead fine, the disc finely sparsely granulate; elytra sparsely punctured basally, becoming rugose at the middle, the tips tumid and finely sparsely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral narrowed apically, the apex deeply rather narrowly emarginate, the base of the emargination rather sharply rounded; seventh ventral elongate, stout, narrowing slightly to the tip which is acutely notched. Lateral view; seventh ventral rather strongly ascending from near the base, the tip beveled beneath; penultimate dorsal slightly extended, the apex truncately rounded; dorsal accessory process stout, clavate.

The single male at hand, Redwood City, California, seems to fit Dr. Fall's description rather well save for the accessory processes which were apparently extended in the type. Of these processes Fall says, " . . . a long curved ligula narrower than the seventh ventral, above which it lies, horizontally flattened and notched at tip and on either side of this a very slender straight needle like process." Such processes are more or less retractile and it may be that the needle like processes are completely concealed in the specimen at hand.

MALTHODES TULARENSIS Fall

Malthodes tularensis Fall, Ann. Ent. Soc. Am. 12, pp. 41-42.

No specimen has been seen that fits this description and unfortunately the types have not been available for study. Fall's description of the species is as follows:

"Fuscous, thorax yellowish, more or less tinged with testaceous, especially along the side margins. Antennae entirely fuscous, as long as the body in the male; third joint scarcely longer than the second, fourth evidently longer, intermediate joints four times as long as wide. Head evidently wider than the thorax, eyes moderately prominent. Thorax quite strongly transverse, sides straight and parallel, rather strongly margined. Length (head deflexed) 2.25 mm. to tips of elytra.

"Abdominal sexual characters. Male: Sixth ventral very deeply, broadly emarginate, the emargination truncate at bottom, seventh narrow, very elongate, polished, yellow, very sparsely pubescent, forked; as viewed in profile, horizontal in rather more than basal half, then rather abruptly sinuately ascending; last dorsals not produced."

Fall's sketch indicates that the seventh ventral is thickened and terete. The last dorsals are not produced. These characters would place the species in the present group.

GROUP VI

1. Seventh ventral apically clavate ..... *similis*
   Seventh ventral with the apex triangularly notched 2
2. Seventh ventral slender, scarcely extending beyond the tips of the sixth ventral ..... *concavus*
   Seventh ventral stout, extending beyond the tips of the sixth for nearly a third of its exposed length ..... *frisoni*

Malthodes similis new species

Plate VIII; figs. 121, 122

Piceotestaceous, head slightly darker, obscurely paler in front; basal two antennal segments testaceous; pronotum flavous to castaneous, infuscate along the margins, more widely so on the anterior margin; trochanters, apices of coxae and bases and apices of the femora and tibiae testaceous; male terminalia fulvous, last segments infuscate apically; pubescence cinereous and moderately conspicuous. Length 2.5 to 3 mm.

Male: Head transverse, much wider than the pronotum, finely closely granulate behind, becoming finely rugose near the antennae; eyes very large and prominent; antennae stout, extending nearly to the tips of the wings in repose, second and third segments equal, the fourth evidently longer, the intermediate segments about four times as long as wide; pronotum rather small, moderately transverse, the anterior angles obliquely rounded, sides sinuate and slightly converging to the hind angles which are prominent, all the angles rather widely reflexed, marginal bead fine, the disc finely sparsely punctured; elytra sparsely punctured basally, becoming rugose punctate apically.

Female: Head slightly wider than the pronotum; eyes much smaller and less prominent; intermediate antennal segments about twice as long as wide; pronotum normally transverse; basal abdominal segments pale medially.

Male terminalia: Ventral view; sixth ventral dilated, narrowed apically, the apex narrowly deeply emarginate, the base of the emargination rounded and the sides parallel, the segment impressed at the base of the emargination; basal third of the seventh ventral triangular, the apical two thirds narrow and clavate with the tip pointed and attaining the apices of the sixth. Lateral view; sixth ventral enlarged, the apices produced and acuminate; seventh ventral straight, clavate, the tip sharply rounded; last dorsals normal.

Holotype, male; *allotype*, female and four *paratypes*, Oakland, Maryland, July 9 to 12, Hubbard and Schwarz. Types in the collection of the United States National Museum. *Paratypes:* 1, Bladensburg, Maryland, June 17, W. V. Warner; 1, Mountain Lake, Virginia, July 20, L. J. & M. J. Milne; 4, Pen Mar, Pennsylvania, Hubbard & Schwarz; 1, New Jersey, O. Dietz; 7, West Summit, Massachusetts, July 4, 1930, J. C. Briedwell; 1, Starved Rock State Park, Illinois, June 28, 1937, Ross & Burks; 1, Squam Lake, New Hampshire, July 11, 1937, J. W. Green; 1, Antrim, New Hampshire, July 22, 1940, C. A. Frost; 1, Mt. Pocono, Pennsylvania, July 3, 1930, J. W. Green; 21, Scioto County, Ohio, June 1 to 10, 1945, D. J. & J. N. Knull; 4, Monmouth, Maine, July 9, 1935, C. A. Frost; 5, Framingham, Massachusetts, July 4, 1907, C. A. Frost; 1, Ridgeway, Ontaria; 1, Chocorua, New Hampshire; 8, Tyngsboro, Massachusetts, June 12, 1887; 10, Massachusetts; 6, Rumney, New Hampshire, July 18 & 19, 1925, Dar-

lington; 1, Marquette, Michigan, July 8; 1, Detroit, Michigan; 5, Highlands, North Carolina, June 1888, Blanchard collection; Tewk, '68; 1, Hartland, Maine, July 9, N. Banks.

This species has long been confused with and determined as *M. concavus* from which it may readily be separated by the characters cited in the key. It is apparently much the commoner of the two species and covers a much larger known range.

MALTHODES CONCAVUS (LeConte)
Plate VIII; figs. 123, 124

Malthinus concavus LeConte, Proc. Acad. Nat. Sci. Phila. 5, 1851, p. 346. *Malthodes concavus* LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 61.

Piceous; head black, testaceous in front of the antennae, basal two segments of the antennae testaceous; pronotum flavous, darker towards the angles and often ornamented with a discal dark spot of irregular pattern; elytral tumidities testaceous; apical abdominal segments of the male flavous with the apices infuscate; pubescence cinereous and moderately conspicuous. Length 2 to 3 mm.

Male: Head wider than the pronotum, finely rather closely granulate behind the antennae; eyes large and prominent; antennae stout, extending to about the tips of the wings in repose, segments two and three equal, the fourth evidently longer, the intermediate segments about three and a half times as long as wide; pronotum transverse, the anterior angles narrowly reflexed and obliquely rounded, sides sinuate, converging rather more strongly than usual to the hind angles which are sharply rounded and narrowly reflexed, marginal bead rather thick, disc transversely impressed near the anterior margin, the surface finely sparsely punctate; elytra rugose punctate, the tips tumid and finely punctured.

Female: Similar to the male; the eyes not prominent, the head as wide as the pronotum; antennae extending almost to the tips of the elytra, the intermediate segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral inflated, evenly rounded and apically narrowed, emarginate to about the middle, the sides of the emargination parallel to the base which is rounded, three semicircular impressions enclose the base of the emargination; seventh ventral elongate, extended slightly beyond the tips of the sixth, stout basally, narrowing rapidly to near the basal third then slightly expanding to the apex which is shallowly notched. Lateral view; sixth ventral large, the apices produced and acuminate; seventh ventral feebly sinuate, the apex rounded; last dorsals not prolonged, apically truncate.

LeConte knew this species from New Hampshire, Massachusetts and Pennsylvania. For this study, specimens were examined from Litchfield, Connecticut; Albany, Maine; Framingham and Sherborn, Massachusetts; Windgap and Easton, Pennsylvania; Schooleys Mountain, New Jersey.

MALTHODES FRISONI Fender

Plate VIII; figs. 125, 126

Malthodes frisoni Fender, Pan-Pac. Ent. 22, no. 4, 1946, pp. 142-143.

Piceotestaceous; the head dark brown with the front, mandibles and basal antennal segments pale; pronotum yellow, sometimes with the basal and side margins darker; basal abdominal segments pale at the apical angles; male seventh ventral testaceous, becoming infuscate apically; pubescence cinereous, erect, and moderately conspicuous. Length 3.5 to 4 mm.

Male: Head slightly wider than the pronotum, finely sparsely punctured behind; eyes large and prominent; antennae moderately stout, extending to the tips of the wings in repose, segments two and three equal, the fourth about one fifth longer, the intermediate segments about four times as long as wide; pronotum moderately transverse, the anterior angles rounded and narrowly reflexed, the sides straight to faintly sinuate, converging slightly to the hind angles which are prominent, marginal bead thick, the disc finely sparsely punctate; elytra extending to a little beyond the apex of the fifth abdominal segment, sparsely rather coarsely punctured basally, becoming feebly rugose punctate apically.

Female: Similar to the male; the head narrower than the pronotum, the eyes comparatively smaller; antennae shorter, the intermediate segments about three times as long as wide.

Male terminalia: Ventral view; sixth ventral inflated, narrowly deeply emarginate, the base of the emargination rounded, wider than the apical opening; seventh ventral stout, narrowed medially, the apex moderately deeply, triangularly notched, the tips acute and divergent. Lateral view; seventh ventral sinuately ascending, the tips laterally notched; last dorsal short and shallowly angularly emarginate.

The types of this species were collected at Charleston, Illinois and are deposited in the Illinois Natural History Survey collection. Paratypes were from Fountain Bluff, Oakwood, Muncie and Saint Joseph, Illinois and Hempstead County, Arkansas. Additional specimens have been studied from Natchitoches, Louisiana expanding the known range of the species to that area.

GROUP VII

1. Seventh ventral notched 2
   Seventh ventral forked 3
2. Seventh ventral deeply channeled, V shaped in cross section, evenly expanded from base to near apex in profile ..... *canaliculatus*
   Seventh ventral not deeply channeled, apically podiform in profile ..... *obductus*
3. Seventh ventral arcuately ascending, the apex flattened, podiform; ultimate dorsal apically truncate ..... *oregonus*
   Seventh ventral feebly ascending basally, apically shaped like a ducks head; ultimate dorsal rather shallowly emarginate, receiving the seventh ventral in the emargination ..... *anatiformis*

Malthodes canaliculatus new species

Plate VIII; figs. 127, 128

Piceotestaceous; head black with the clypeus and mandibles diffusely paler; antennae piceous; pronotum flavous with a large diffusely darker median spot which reaches the anterior margin, the sides narrowly darker just behind the anterior angles; basal five abdominal segments pale; femora of the front and middle legs paler; pubescence cinereous, inconspicuous. Length 2.5 mm.

Male: Head just visibly wider than the pronotum, finely sparsely punctate behind the eyes which are not appreciably large and prominent; antennae moderately stout, extending to about the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about three and a half times as long as wide; pronotum moderately transverse, the anterior angles rounded, the sides arcuately rounded to the hind angles which are obtusely rounded, narrowly reflexed near the angles, marginal bead fine, disc finely sparsely punctate; elytra punctate basally, becoming rather feebly rugose apically.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination evenly rounded; seventh ventral elongate, about three and a half times as long as wide at its widest part, deeply channeled, the sides feebly expanded at the middle, the apex sharply triangularly nicked. Lateral view; seventh ventral straight, clavate, the tip obtusely pointed; last dorsals prolonged, rather strongly arched, the penultimate truncate, the ultimate bent downward and with a sharp median keel beneath; ventral accessory process short, slender and sinuate; dorsal accessory process moderately large, triangular, the tip acute.

Holotype, male, Scioto County, Ohio, June 10, 1944, D. J. & J. N. Knull, in the Knull collection.

The proper position of this species is questionable. It may be that it should be placed with *M. werneri* and *M. curvatus* on the basis of the deeply channeled (V shaped) seventh ventral and because of its eastern range. It has been more or less tentatively placed in the present group because of the keeled ultimate dorsal although the other members of the group are strictly western.

MALTHODES OBDUCTUS Fall

Plates IX; figs. 129, 130

Malthodes obductus Fall, Ann. Ent. Soc. Am. 12, no. 1, 1919, p. 39.

Brownish testaceous; head darker with the front, mandibles and basal segments of the antennae testaceous; pronotum yellowish with the disc becoming fuscous; sides and apices of the basal and middle abdominal segments yellowish; apical abdominal segments of the male yellowish, of the female brunneous; pubescence cinereous, fine and inconspicuous. Length 2.5 to 3 mm.

Male: Head slightly wider than the pronotum, sparsely rather coarsely granulate behind the antennae; eyes moderately small, separated by nearly two and a half times their width as viewed frontally; antennae moderately slender,

extending to the tip of the abdomen, segments two to four increasing in length, the intermediate segments about four and a half times as long as wide; pronotum transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides nearly straight, converging slightly to the hind angles which are obtuse and narrowly reflexed, marginal bead rather thick, disc finely punctate, becoming slightly scabrose medially; elytra confusedly punctured, becoming rugose apically.

Female: Similar to the male; head slightly narrower than the pronotum, the eyes smaller; antennae extending to the elytra apices, the intermediate segments about three times as long as wide.

Male terminalia: Ventral view; sixth ventral deeply moderately widely emarginate, the base of the emargination evenly rounded; seventh ventral elongate, extending beyond the sixth by about one and a quarter times the length of that segment, stout basally, the sides sinuately converging to the apex which is triangularly notched, the tips acute. Lateral view; seventh ventral stout basally, evenly narrowed to the apical third where it becomes podiform; penultimate dorsal strongly arched and prolonged, subtruncate and expanded apically, a median keel beneath; ultimate dorsal not exposed; ventral accessory process about one fourth the length of the seventh ventral, slender, clavate with the tip rounded; dorsal accessory process short, subtriangular with the free angle rounded.

The type locality of this species is Green Point, Humboldt, California. Fall also included in his series some specimens from Seattle, Washington in which: "the segment is more deeply cleft, the forks diverging and the tip of the produced fifth dorsal is a little different." He conceded that a closely allied species might be represented but preferred to consider it a varietal form. The Seattle specimens were apparently of the species *M. oregonus*.

Specimens of *M. obductus* have been examined from the following California localities: Green Point, Humboldt County (paratypes); Redwood Creek, Humboldt County; Blue Lake, Humboldt County; Muir Woods, Marin County; Lake County.

MALTHODES OREGONUS Fender ?

Plate IX; figs. 131, 132

Malthodes oregonus Fender, Pan-Pac. Ent. 19, no. 2, 1943, pp. 66-67.

Head black with the front, mandibles and first two antennal segments pale testaceous, remainder of the antennae piceous; pronotum testaceous with a median discal spot that is fuscous, occasionally divided by the median impressed line; elytra brownish testaceous to nearly piceous, paler at the tips; body beneath piceotestaceous; tibiae and apices of the femora of the front legs pale; apices of the femora and basal half of the tibiae of the middle and hind legs pale; pubescence cinereous. Length 3 to 3.5 mm.

Male: Head slightly wider than the pronotum, finely rather sparsely granulose behind the antennae; eyes small and not very prominent; antennae moderately slender, extending to the tips of the wings in repose, second and

third segments equal, the fourth longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely rounded and narrowly reflexed, the sides sinuate, converging slightly to the hind angles which are rounded, marginal bead rather thick, the disc moderately coarsely punctured, somewhat rugulose medially, a median longitudinal impressed line extending from the base to the apex, sometimes becoming obscured medially by the discal rugae; elytra rather closely coarsely punctured, becoming somewhat rugulose medially, the tips slightly tumid and finely punctured.

Female: Similar to the male; head equal to the pronotum in width, the eyes slightly smaller; antennae extending to a little beyond the elytral apices, the intermediate segments about three times as long as wide.

Male terminalia: Ventral view; sixth ventral deeply emarginate, the base of the emargination angulate; seventh ventral furcate apically, the forks widely separated, becoming nearly parallel apically, the tips rounded. Lateral view; seventh ventral strongly sinuate, stout, becoming podiform at a little beyond the middle; last dorsals strongly arched, broadened and truncate apically, strongly keeled beneath; ventral accessory process short, narrow and rod like; dorsal accessory process subtriangular with the free angle rounded.

This species ranges from southern Oregon into British Columbia. Material was studied from the following localities: *Oregon;* Blodgett, Corvallis, Dayton, Grants Pass, Klamath Lake-Lake of the Woods Highway, McMinnville, Newport, Olney, Peavine Ridge (McMinnville), Portland, Spencers Butte (Eugene). *Washington;* Baker Lake (Mt. Baker), Bothel, Chambers Creek (Pierce County), Chase Lake, Evans Lake, Fall City, Fort Lewis, Friday Harbor, Kirkland, La Conner, Lake St. Clair, Manchester, Martha Lake (nr. Edmunds), Olympia, Seattle, Skokomish River, Tenino. *British Columbia;* Fenie, Nanaimo, North Bend, Pender Harbor, Steelhead, Vancouver.

Malthodes anatiformis new species
Plate IX; figs. 133, 134

Head piceous, the clypeus and mandibles pale, antennae fuscous with the basal segment pale; pronotum yellowish with an obscurely darker median spot; elytra piceotestaceous with the apical tumidities pale olivaceous; legs piceous with the femora and basal half of the tibiae of the front legs and apices of the femora and bases of the tibiae of the middle and hind legs pale; pubescence cinereous. Length 3.5 mm.

Male: Head small, as wide as the pronotum, finely sparsely granulate behind the antennae; eyes small and not very prominent; antennae moderately stout, extending to the tips of the wings in repose, the basal segment unusually long and apically dilated, segments two and three equal, the fourth evidently longer, the intermediate segments about three and a half times as long as wide; pronotum transverse, the anterior angles obliquely rounded and narrowly reflexed, the sides nearly straight, converging slightly to the obtusely rounded hind angles which are not appreciably reflexed, marginal bead fine,

disc finely sparsely granulate; elytra sparsely confusely punctate basally, becoming rugose medially, the tips tumid and finely sparsely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination sharply rounded; seventh ventral stout, narrowed medially, forked at about the apical third, the forks stout, base of the furcation acute; last dorsals narrowly triangular, apices of the arched penultimate dorsal obliquely divergent. Lateral view; seventh ventral sinuately ascending, dorsally knobbed at the apical third giving the segment somewhat the appearance of a duck's head; last dorsals prolonged and arched with a narrow median keel beneath, the apex of the penultimate dorsal shallowly emarginate, partially receiving the seventh ventral; ultimate dorsal not exposed; ventral accessory process slender, spinose, feebly upcurved apically.

Holotype, male, Carrville, Trinity County, California, June 3, 1913, E. C. Van-Dyke, in the collection of the California Academy of Sciences. *Paratypes:* 2, Fallen Leaf Lake, Eldorado County, California, July 4 & 6, 1935, F. E. Blaisdell; 1, Dunsmuir, California, Wickham; 1, Shasta County, California, June 26, 1921, J. A. Kusche.

GROUP VIII

KEY TO THE SPECIES

1. Seventh ventral stout, with a wide, deep triangular apical notch, last dorsal arcuately emarginate apically, bent down and forward in repose and receiving the middle of the seventh ventral in the emargination ..... *rotgeri*
   Seventh ventral less stout, apically forked, last dorsal received in the fork 2
2. Seventh ventral arcuate in profile, at most the tips spherical and slightly bent down 3
   Seventh ventral sinuate or sigmoidal in profile 5
3. Forks of seventh ventral strongly divergent, more strongly so apically, in profile, the seventh ventral strongly ascending apically, the tips extending above the horizontal plane of the dorsals, last dorsal short ..... *diegae*
   Forks of seventh ventral apically parallel or at best moderately divergent, in profile moderately arcuate, the tips not approaching the horizontal plane of the dorsals, last dorsal long 4
4. Forks of seventh ventral parallel apically, the tips not knobbed ..... *chiricahuae*
   Forks of seventh ventral straight, moderately divergent, the tips knobbed ..... *fuliginosus*
   A. pronotum piceous to piceotestaceous with the anterior and posterior margins narrowly pale ..... *fuliginosus* s. str.
   B. pronotum entirely flavous ..... var. *flavicollis*
5. Seventh ventral sinuate in profile ..... *margaritae*
   Seventh ventral sigmoidal in profile, the forks expanded into thin fusiform plates ..... *niger*

MALTHODES ROTGERI Fender

Plate IX; figs. 135-137

Malthodes rotgeri Fender, Pan-Pac. Ent. 22, no. 4, pp. 143-144.

Nigropiceous to black; pronotum with the basal and apical margins narrowly pale, varying to flavous with the sides and a longitudinal median stripe dark; male terminalia testaceous with the apices of the seventh ventral and last dorsal infuscate; pubescence cinereous, fine and inconspicuous. Length 3.5 to 4 mm.

Male: Head slightly wider than the pronotum, finely sparsely punctured; eyes moderately large and prominent; antennae rather close together the inter-

antennal area V shaped, moderately slender, extending to about the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles rounded, the sides arcuate, converging slightly to the hind angles which are obtusely rounded, marginal bead fine, disc finely sparsely punctured; elytra extending to the apex of the fifth abdominal segment, finely sparsely punctured basaliy, becoming feebly rugose medially and more evidently so apically.

Female: Similar to the male, eyes smaller, the pronotum more evidently narrowed basally; antennae extending to about the elytral apices, the intermediate segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral moderately deeply emarginate, the base of the emargination truncate; seventh ventral elongate, stout, narrowed medially, widely deeply notched at the apex, the notch triangular, the tips acute. Lateral view; seventh ventral arcuate, the tips sharply rounded; last dorsals produced, the ultimate shallowly emarginate apically, produced downward and forward in repose, receiving the seventh ventral in the emargination.

Described from Pagosa Springs, Colorado, additional specimens have been seen from West Cliff, Colorado, White Mountains, Arizona and Cloudcroft, New Mexico.

Malthodes diegae new species

Plate IX; figs. 138, 139

Piceotestaceous; the head darker behind the eyes, the mandibles pale; pronotum flavous with the sides narrowly infuscate near the anterior angles; last dorsal and all but the tips of the seventh ventral of the male testaceous; pubescence cinereous, fine, sparse and inconspicuous. Length 3.25 mm.

Male: Head wider than the pronotum, finely sparsely granulose behind the eyes, more closely so at the sides; eyes large and prominent, separated by about one and a half times their width as viewed frontally; antennae long and slender, extending beyond the tips of the wings in repose by about the apical segment; segments two and three equal, the fourth longer, the intermediate segments fully five times as long as wide; pronotum moderately transverse, the anterior angles evenly rounded, not appreciably reflexed, the sides feebly sinuate, parallel to the hind angles which are moderately prominent, marginal bead rather thick becoming finer on the anterior margin, disc finely sparsely punctured; elytra long, extending nearly to the tip of the abdomen, finely punctured basally, becoming finely rugose punctate apically.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral strongly produced at the sides, widely emarginate, the base of the emargination rounded; seventh ventral elongate, apically forked to the middle, the forks strongly divergent, receiving the produced last dorsal; last dorsal shallowly notched apically. Lateral view; seventh ventral strongly ascending, the tips becoming vertical

and extending above the plane of the dorsals; last dorsals produced, the penultimate short and transverse, the ultimate narrow, received in the furcation of the seventh ventral.

Holotype, male, San Diego, California, no date, collected by F. E. Blaisdell, in the collection of the California Academy of Sciences.

Malthodes chiricahuae new species

Plate IX; figs. 140-142

Piceous, the head darker, pronotum flavous with the sides narrowly black, wide anterior, narrower transverse median and smaller basal dark spots on the disc, the edges of these markings poorly outlined; elytral apices fuscotestaceous; trochanters, apices of the coxae and femora and bases of the tibiae pale; male terminalia testaceous with the apex of the seventh ventral infuscate; pubescence cinereous, fine, sparse and inconspicuous. Length 3.5 mm.

Male: Head slightly wider than the pronotum, finely sparsely granulose; eyes moderately large and prominent; antennae slender, extending slightly beyond the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely rounded and narrowly reflexed, the sides sinuate, converging slightly to the hind angles which are obtuse, a median longitudinal impressed line extends from the anterior margin to the apical third, marginal bead fine, disc finely sparsely granulose; elytra long, extending to the apex of the sixth ventral, finely punctured basally, becoming rugose punctate medially, the tips tumid and finely punctured.

Female: Similar to the male; eyes smaller and less prominent; antennae extending to the tips of the elytra, the intermediate segments about three times as long as wide; sides of the pronotum straight and parallel; elytra extending to the middle of the fifth abdominal segment.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination rounded; seventh ventral stout, widely forked at the apical third, receiving the furcate tips of the last dorsal. Lateral view; seventh ventral straight to the middle then ascending to the tips which are acute; last dorsals prolonged and strongly arched, the penultimate shorter than the ultimate which is received in the furcation of the seventh ventral, ventral surface of the ultimate dorsal sinuate. As viewed caudally: ultimate dorsal expanded apically and widely shallowly forked, the base of the furcation truncate.

Holotype, male, Rustler Park, Chiricahua Mountains, Arizona, July 27, 1927, collected by Kusche. *Allotype*, female, Flye Pk., Chiricahua Mountains, Arizona, July 9, 1927, Kusche. Types in the collection of the California Academy of Sciences.

MALTHODES FULIGINOSUS LeConte

Plate X; figs. 143, 144

Malthodes fuliginosus LeConte, Smiths. Misc. Coll. 6, no. 167, 2nd ed., 1866, p. 93. *Malthodes fuliginosus* LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 62.

Piceous; head black with the apex of the clypeus and the mandibles

flavous, basal one or two antennal segments testaceous; anterior and posterior margins of the pronotum narrowly testaceous; male terminalia testaceous sometimes with the apices becoming infuscate; pubescence cinereous, moderately conspicuous. Length 3.5 to 4 mm.

Male: Head wider than the pronotum, closely rather coarsely granulate behind the antennae; eyes large and prominent; antennae stout, extending to a little beyond the tips of the elytra, segments two to four progressively longer, the intermediate segments about three and a half times as long as wide; pronotum transverse, the anterior angles obliquely truncated, becoming produced at the sides which are straight and rather strongly convergent (for the genus) to the prominent, sharply rounded hind angles, the angles narrowly reflexed, marginal bead fine, disc finely rather closely granulate; elytra finely punctate basally, becoming rugose apically.

Female: Similar to the male, the pronotal margins more widely pale; antennae extending almost to the elytral apices, the intermediate segments about three and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral emarginate to about the basal fourth, sides of the emargination strongly converging to the base which is rounded; seventh ventral stout, prolonged, extending beyond the sixth by about two and a half times the length of that segment, forked to about the middle, sides slightly converging to the base of the furcation, forks slightly divergent to the tips which are knobbed. Lateral view; seventh ventral arcuate with the tips slightly bent down and knobbed; last three dorsal prolonged, strongly arched over the seventh ventral, the penultimate apically truncate, the ultimate strongly deflexed, received in the fork of the seventh ventral, its dorsal surface straight to near the tip where it becomes beveled, the ventral surface widely keeled. As viewed caudally; ultimate dorsal narrowly notched medially.

Lake Superior and New Hampshire were cited by LeConte as areas where this species was known. Additional material has been studied from Marquette, Michigan; West River, Nova Scotia; Dryden and Upper Saranac, New York and Lake Willoughby, Vermont.

Malthodes fuliginosus var. **flavicollis** new variety

Head black with the front, mandibles and basal antennal segments flavous, the remainder of the antennae fuscous; pronotum a clear yellow with the sides near and including the anterior angles narrowly infuscate; scutellum and the elytra piceous with the tips of the elytra olivaceous; legs brownish with the tips of the femora and tibiae paler.

Holotype, male, Hocking County, Ohio, May 23, D. J. & J. N. Knull. *Allotype*, female, Hocking County, Ohio, May 20, D. J. & J. N. Knull. 67 *paratypes* from the following localities: Ramsey, New Hampshire; Hancock, Dryden, Olcott, Ithaca and Mt. Whiteface, New York; Highlands, North Carolina; West River, Nova Scotia; Delaware County and Hocking County, Ohio; Gatlinburg, Great Smoky Mountain National Park, Tennessee. Types in the Knull collection.

Malthodes margaritae new species
Plate X; figs. 145, 146

Testaceous; the pronotum pale flavous with a large median spot and the anterior angles faintly infuscate; head brownish with the front paler, the antennae piceotestaceous with the basal segments apically annulate, the first segment flavous; the tumidities of the elytral apices yellowish; pubescence cinereous, inconspicuous. Length 3 mm.

Male: Head wider than the pronotum, virtually impunctate in front, feebly sparsely granulose behind the antennae; eyes moderately large and prominent; antennae slender, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about three and a half times as long as wide; pronotum moderately transverse, the anterior angles rounded, narrowly reflexed, the sides straight, converging slightly to the prominent, rounded hind angles, marginal bead fine on the anterior margin, thicker at the sides and base, disc finely sparsely punctate, becoming minutely granulate towards the sides; elytra sparsely punctured basally, becoming feebly rugose medially, the apices tumid and smooth.

Female: Similar to the male; the antennae extending to the elytral apices, the intermediate segments about two and a half times as long as wide; head only slightly wider than the pronotum, the eyes smaller and less prominent; disc of the pronotum finely sparsely granulate throughout.

Male terminalia: Ventral view; sixth ventral short, deeply moderately widely emarginate, the base of the emargination rounded; seventh ventral elongate, extending beyond the sixth by about twice the length of that segment, stout basally, narrowing to the middle where it is forked, the forks straight and divergent, base of the furcation sharply rounded; last dorsals prolonged, triangularly narrowed; dorsal accessory process exposed near the base of and at the sides; seventh ventral as subacute diagonally produced spines. Lateral view; seventh ventral sinuate, the tips acute; last dorsals produced and arched, the ultimate subspatulate; dorsal accessory process stout basally, the tip narrow and hooked.

Holotype, male; *allotype,* female and 11 *paratypes,* Park Camp, Wenatchee National Forest, Washington, July 8, 1948, C. P. Alexander; two paratypes, Easton, Washington, collected by Koebele. Types in the collection of the California Academy of Sciences.

It gives me great pleasure to dedicate this species to Mrs. M. M. Alexander, helpmate and pal of Dr. C. P. Alexander, the eminent tipulid specialist. Fortunate indeed is this man who managed to marry a humorist, cook, chauffeur, stenographer, proof reader and ardent supporter—all one individual.

MALTHODES NIGER (LeConte)
Plate X; figs. 147, 148

Malthinus niger LeConte, Proc. Acad. Nat. Sci. Phila. (2) 5, 1851, p. 346. *Malthodes niger* LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 62.

Pale piceous to black; mandibles, basal two antennal segments, trochanters and apices of the coxae pale; last two dorsals and basal half of the last ven-

tral of the male pale; pubescence cinereous, inconspicuous. Length 3 to 3.5 mm.

Male: Head wider than the pronotum, finely sparsely punctate behind the antennae; eyes moderately large and prominent; antennae extending to the tips of the elytra, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum transverse, the sides parallel from the obliquely truncated anterior angles to the hind angles which are prominent, marginal bead thick, disc feebly sparsely granulate, the tiny granules more evident near the base; elytra extending to the apex of the sixth ventral, sparsely punctured basally, becoming rugose medially, the tips feebly tumid and finely punctured.

Female: Similar to the male; the head slightly wider than the pronotum, the eyes smaller and less prominent; antennae extending to the tips of the elytra, the intermediate segments about three and a half times as long as wide; hind angles of the pronotum obtusely rounded.

Male terminalia: Sixth ventral widely emarginate, the base of the emargination subtruncate; seventh ventral elongate, sigmoidally ascending, forked at about the apical third or more, the forks dilated into thin crescent shaped plates; penultimate dorsal elongate, apically truncate, concave beneath with a large lateral deflexed marginal tooth near the apex; ultimate dorsal narrow, deflexed and received in the fork of the seventh ventral.

Previously recorded from Lake Superior and Mount Washington, New Hampshire, additional specimens have been examined from Heart Lake, Essex County, New York; McLean Bogs, Tompkins County, New York; Rock City, Cattaraugus County, New York; Duparquet, Quebec; Isle Royal, Lake Superior.

GROUP IX

1. Seventh ventral partially enveloped by the apical side pieces of penultimate dorsal; ventral accessory process exposed, straight, rodlike ..... *fusculus*
   Seventh ventral not partially enveloped by apical side pieces of penultimate dorsal; ventral accessory processes, if present, concealed 2
2. Pronotum entirely pale; seventh ventral with an obtuse tooth medially on the dorsal surface ..... *bicurvatus*
   Pronotum bicolored; seventh ventral without a tooth medially on the seventh ventral 3
3. Pronotum with sides and a broad median stripe infuscate; penultimate dorsal side pieces stout, angulately incurved apically, a sharp spine on inner side of the angulation ..... *bisinuatus*
   Pronotum piceous, becoming obscurely paler at the angles; penultimate dorsal side pieces short, straight, converging apically, subtriangular in ventral view; sixth ventral trifoliately emarginate ..... *tumidicollis*

MALTHODES FUSCULUS (LeConte)

Plate X; figs. 149, 150

Malthinus fusculus LeConte, Proc. Acad. Nat. Sci. Phila. (2) 5, 1851, p. 346. *Malthodes fusculus* LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 61. *Malthodes fusculus* Fall, Ann. Ent. Soc. Am. 12, 1919, p. 41.

No specimen fitting LeConte's description has been seen. "Last abdominal segments of male with long complex processes; last dorsals not prolonged;

last ventral segment narrow, bent in a sinuate manner obliquely upward and more deeply nicked at tip than in *fragilis*, prothorax transverse, finely margined, tinged with testaceous; head black, eyes large, prominent, antennae long, slender, fourth and following joints longer than second and third, male two thirds, female one half as long as the body. Length 3 mm.; Cal."

Floyd Werner again has sketched the male terminalia of the type. Diagrammatic copies of these sketches are included in the plates. They indicate that *M. fusculus* should be assigned to this group, not near *fragilis* as placed by LeConte nor near *vapidus* as by Fall.

Male terminalia: Ventral view; sixth ventral somewhat prolonged, widely very deeply emarginate, the base of the emargination sharply rounded, the sides of the emargination sinuate; seventh ventral elongate, extending beyond the sixth for about one fourth of its length, slightly narrowed medially and at the apex which is deeper subtriangularly notched, the tips acute; tips of the descending side pieces of the penultimate dorsal incurved somewhat, enclosing the seventh ventral. Lateral view; sixth ventral prolonged; seventh ventral bisinuately ascending, narrow; penultimate dorsal short, the side pieces apically descending, trapezoidal; ultimate dorsal not exposed; ventral accessory elongate, feebly ascending apically.

MALTHODES BICURVATUS Fall

Plate X; figs. 151, 152

Malthodes bicurvatus Fall, Ann. Ent. Soc. Am. 12, 1919, pp. 39-40.

Fuscotestaceous; mandibles pale; pronotum flavous; trochanters, apices of the coxae and bases of the femora paler; male terminalia testaceous; pubescence cinereous. Length 2 to 3 mm.

Male: Head slightly wider than the pronotum, finely sparsely punctured behind the antennae; eyes small and not prominent; antennae moderately stout, extending to a little beyond the elytral apices, second and third segments equal, the fourth distinctly longer, the intermediate segments nearly five times as long as wide; pronotum transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides feebly sinuate and slightly converging to the obtuse hind angles, marginal bead fine, disc finely sparsely granulate; elytra rugose throughout, less strongly so basally.

Female: Similar to the male; antennae extending nearly to the elytral tips, the intermediate segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral expanded apically, broadly deeply emarginate, the base of the emargination evenly rounded; seventh ventral moderately narrowed at basal and apical thirds, rather strongly expanded at the base and middle, much less but evidently so near the apex which is narrowly sharply notched. Lateral view; seventh ventral bisinuate, an obtuse tooth medially on the dorsal surface; sides of the penultimate dorsal produced ventrad and caudad in a long spatulate process that is slightly inflated apically and encloses the seventh ventral somewhat, frequently concealing the median tooth of that segment, apex of the penultimate dorsal subtruncate; ultimate dorsal not exposed.

Fall described this species from specimens collected at Mokelumne Hill and Adams Spring, Lake County, California. Paratypes from the Mokelumne Hill locality have been studied as well as other material from the following California localities: Sonoma County, Los Gatos, Auburn, Fort Seward, Muir Woods (Marin County), Sonora (Tuolumne County).

Malthodes bisinuatus new species
Plate X; figs. 153, 154

Piceotestaceous; head darker except for the mandibles which are pale; antennae and legs piceous; pronotum flavous with the sides narrowly and a broad median stripe infuscate; elytral apices yellowish; male terminalia testaceous; pubescence cinereous, moderately conspicuous. Length 3.5 mm.

Male: Head as wide as the pronotum, finely sparsely punctate behind the antennae; eyes small and not prominent; antennae slender, extending to the tips of the wings in repose, segments two and three equal, the fourth longer, the intermediate segments about four times as long as wide; pronotum moderately transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides nearly straight, converging slightly to the obtuse hind angles which are narrowly reflexed, marginal bead fairly thick basally and at the sides, finer on the anterior margin, disc finely sparsely granulate, more closely so near the hind angles; elytra confusedly punctate basally, becoming rugose medially, the tips tumid and finely punctate.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral deeply rather narrowly emarginate, the base of the emargination angulate; seventh ventral elongate, sides sinuately subparallel, the apex notched, the notch deeper than wide, the tips rounded; caudad projecting side pieces of the penultimate dorsal stout, angled inwardly at about the basal third, apices knobbed, each armed with a spine on the inner ventral surface and slightly behind the angulation. Lateral view; seventh ventral bisinuate, extending slightly beyond the prolonged side pieces of the penultimate dorsal; side pieces of the penultimate dorsal angulately deflexed at the basal third, bearing a spine on the inner ventral surface; ultimate dorsal not exposed.

Holotype, male, San Mateo, County, California, May 19, 1918, E. P. VanDuzee, in the collection of the California Academy of Sciences.

Malthodes tumidicollis new species
Plate X; figs. 155, 156

Nigropiceous; head black with the mandibles pale; pronotum with the margins rather widely but obscurely paler at the angles; male terminalia testaceous with the apices of all exposed portions infuscate; pubescence cinereous, fine and inconspicuous. Length 3.5 mm.

Male: Head wider than the pronotum, finely sparsely granulose behind the antennae; eyes moderately large and prominent; antennae extending to the tips of the wings in repose, segments two and three equal, the fourth

evidently longer, the intermediate segments about four and a half times as long as wide; pronotum moderately transverse, the anterior angles obliquely truncated, the sides straight, converging slightly to the hind angles which are produced, marginal bead rather thick, disc finely sparsely granulose, a rather long transverse tumidity on the middle of each lateral half; elytra extending to the apex of the fourth abdominal segment, finely rugose punctate to the tips which are feebly tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral widely and deeply trifoliate emarginate, slightly produced, the apices rounded; seventh ventral elongate, narrowing evenly to the apical third where it rather suddenly broadens then narrows to the apex which is triangularly notched, the tips acute; side pieces of the penultimate dorsal subclavate with a short spine medially on the inner surface. Lateral view; seventh ventral bisinuate, evidently narrowed at the basal fourth and expanded medially then evenly narrowed to the tip; side pieces of the penultimate dorsal produced ventrad and caudad as a broadly rectangular plate having a small short spine medially on the lower edge; ultimate dorsal not exposed.

Holotype, male, Pygmy Forest, Fort Bragg, Mendocino County, California, June 14, 1948, H. B. Leech, in the collection of the California Academy of Sciences. Mr. Leech collected a teneral female at the same time the type was taken but it was in such a crumpled condition that it was considered inadvisable to associate it with this species especially as a member of the type series.

GROUP X

1. Sides of penultimate dorsal evenly produced ventrad, the apex truncate ..*diamondensis*
   Sides of penultimate dorsal unevenly produced ventrad, intricately developed 2
2. Produced side pieces of penultimate dorsal triangularly produced ventrad 3
   Produced side pieces of penultimate dorsal not triangular 9
3. Triangularly produced side pieces of penultimate dorsal narrow, tips acute, apex of seventh ventral triangularly notched ..... *sinuatus*
   Triangularly produced side pieces of penultimate dorsal wide, seventh ventral apically forked 4
4. Seventh ventral forked beyond apical fourth ..... *humidus*
   Seventh ventral forked before apical fourth 5
5. Free angle of triangularly produced side pieces of penultimate dorsal nearly 90° .. 6
   Free angle of triangularly produced side pieces of penultimate dorsal nearly 45° .. 7
6. Seventh ventral forked for nearly one half its length, the tips acute ..... *intermedius*
   Seventh ventral forked for one third its length, the tips rounded ..... *orovillensis*
7. Base of furcation of seventh ventral rounded, the tips rounded ..... *visceratus*
   Base of furcation of seventh ventral acute, the tips acute 8
8. Seventh ventral medially armed with a short acute spine on the dorsal surface .... *spinicaudus*
   Seventh ventral unarmed on the dorsal surface ..... *forficatus*
9. Side pieces of penultimate dorsal cultriform ..... *complicatus*
   Side pieces of penultimate dorsal not cultriform 10
10. Side pieces of penultimate dorsal narrowly podiform 11
    Side pieces of penultimate dorsal not narrowly podiform 12
11. Seventh ventral apically notched ..... *blackwelderi*
    Seventh ventral apically forked ..... *lawrencei*
12. Side pieces of penultimate dorsal arcuately produced ventro-caudad, sides of the projection concentric and the apex truncate ..... *eximius*
    Side pieces of penultimate dorsal not so 13

13. Side pieces of penultimate dorsal broadly sinuately produced ventrad, the apex sub-truncate 14
Side pieces of penultimate dorsal digitate or ovate 15
14. Seventh ventral nearly straight in profile ..... *furcifer*
Seventh ventral evidently sinuate in profile ..... *macnabi*
15. Side pieces of penultimate dorsal elongate, digitate 16
Side pieces of penultimate dorsal large, ovate 18
16. Seventh ventral sinuate in profile ..... *vandykei*
Seventh ventral not sinuate in profile 17
17. Seventh ventral evenly curved in profile, narrowed from base to apex ..... *vanduzeeana*
Seventh ventral straight, dilated beyond basal third in profile, the apex beveled beneath ..... *complexipygus*
18. Seventh ventral feebly bent up at the middle, forked for one half or more of its length 19
Seventh ventral sinuately ascending, forked for less than half its length 20
19. Forks of seventh ventral parallel apically ..... *singularis*
Forks of seventh ventral divergent throughout ..... *sericeiventris*
20. Seventh ventral unevenly sinuate, strongly ascending from near the base to the extent that a nearly caudal view is required to examine the forks 21
Seventh ventral more evenly sinuate, less strongly ascending, the forks readily visible from a ventral view 22
21. Seventh ventral forked for about one fourth of its length, narrowed at the apical third, the tips convergent apically ..... *abruptus*
Seventh ventral forked for about a third of its length, narrowest at the middle, the tips slightly divergent apically ..... *piperi*
22. Forks of seventh ventral straight, V shaped 23
Forks of seventh ventral curved, U shaped 24
23. Seventh ventral narrowest before the base of the furcation (ventral view), main body of penultimate dorsal vertical ..... *acuticaudus*
Seventh ventral narrowest at the base of the furcation (ventral view), main body of penultimate dorsal diagonal ..... *bakeri*
24. Side pieces of penultimate dorsal not narrowed at the base, forks of seventh ventral parallel for two thirds their length ..... *contortus*
Side pieces of penultimate dorsal narrowed at the base, forks of seventh ventral curved or parallel for one half or less of their length 25
25. Ultimate dorsal elongate, narrowly conical, the tip truncate, seventh ventral forked for two fifths or more of its length 26
Ultimate dorsal expanded into a large subquadrate vertical plate, seventh ventral forked for one third or less of its length ..... *frosti*
26. Ultimate dorsal straight in profile, main body of penultimate dorsal short and diagonal, seventh ventral forked for two fifths of its length ..... *intricatus*
Ultimate dorsal curved in profile, main body of penultimate dorsal long and horizontal, seventh ventral forked for one half of its length ..... *idahoensis*

Malthodes diamondensis new species

Plate XI; figs. 157, 158

Piceous; head slightly darker, the clypeus and mandibles pale; pronotum flavous with the sides near the anterior angles infuscate; trochanters and bases of the tibiae testaceous; pubescence cinereous, sparse and inconspicuous. Length 3 to 3.5 mm.

Male: Head wider than the pronotum, finely granulose behind the antennae; eyes large and prominent; antennae extending to the tips of the wings in repose, segments two and three equal, the fourth evidently longer, the intermediate segments about four times as long as wide; pronotum strongly trans-

verse, the anterior angles widely reflexed and rounded, the sides feebly sinuate, converging to the hind angles which are obtuse and widely reflexed, marginal bead fine; disc finely sparsely punctured, a median longitudinal impressed line extends from the base to about the apical third; elytra confusedly punctate basally, becoming rugose apically.

Female: Similar to the male; head slightly narrower than the pronotum, the eyes less prominent; antennae extending to about the elytral tips, the intermediate segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral inflated, moderately emarginate, the emargination trifoliate; seventh ventral stout, the apex broadly deeply forked, the forks divergent throughout their length. Lateral view; sixth ventral elongate, slightly descending apically; last dorsals prolonged, sides of the penultimate dorsal strongly descending laterally and enveloping the seventh ventral leaving only the apical third of that segment exposed, the penultimate apically truncate; ultimate dorsal normally small.

Holotype, male; *allotype,* female and three *paratypes,* Diamond Lake, Oregon, July 27, 1941, K. M. & D. M. Fender, in the collection of the California Academy of Sciences.

Malthodes sinuatus new species

Plate XI; figs. 159, 160

Head black, the apical margin of the clypeus narrowly pale, the mandibles flavous with the tips becoming brunneous; antennae piceous with the basal segments pale; pronotum flavous with a brunneous stripe extending medially from the apex to the base; sides brunneous, these brunneous areas extending triangularly inward and feebly connecting with the discal stripe to give the ornamentation the appearance of a rather diffuse cross; scutellum testaceous; elytra piceotestaceous, the tips obscurely paler; trochanters pale, apices of the coxae and femora and bases of the femora and tibiae rather widely pale; male terminalia yellowish; pubescence cinereous, inconspicuous. Length 3 mm.

Male: Head wider than the pronotum, finely sparsely granulate behind the antennae; eyes large and prominent; antennae slender, extending to the tips of the elytra, segments two to four progressively longer, the intermediate segments almost five times as long as wide; pronotum transverse, the anterior angles obliquely truncated, the sides feebly sinuate, converging slightly to the prominent hind angles, reflexed near the anterior angles, marginal bead fine, disc finely rather closely granulate, a median impressed line extends from the base to the apex; elytra unusually long, extending beyond the tips of the abdomen, finely rather closely punctured basally becoming rugose punctate apically.

Female: Similar to the male; antennae and elytra shorter, intermediate segments of the antennae about three times as long as wide.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination subtruncate; seventh ventral elongate, the sides narrowed medially and again at the apex which is shallowly notched. Lateral view; seventh ventral strongly sinuate, expanded near the apex; penultimate dorsal side pieces produced ventrad and backward in an acutely triangular

process, the apex of the penultimate produced in the form of a rounded canopy; ultimate dorsal normal; ventral accessory process short and truncate, tipped with long hairs.

Holotype, male and *allotype*, female, McKenzie Bridge, Oregon, May 3, 1947, Borys Malkin, in the collection of the California Academy of Sciences.

MALTHODES HUMIDUS Fender

Plate XI; figs. 161, 162

Malthodes humidus Fender, Pan-Pac. Ent. 19, no. 2, 1943, pp. 68-69.

Piceous to nigropiceous; head darker with the mandibles testaceous; pronotum varying from piceous to flavous with the margins widely dark, more widely so medially on the basal and apical margins; male terminalia including the base of the emargination of the sixth ventral flavous; female last abdominal segments dark; pubescence cinereous, fine and rather inconspicuous. Length 3 to 3.5 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes large and prominent; antennae slender, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments nearly five times as long as wide; pronotum strongly transverse, the anterior angles rounded and narrowly reflexed, the sides sinuate, converging slightly to the hind angles which are prominently rounded, marginal bead fine on the anterior margin becoming thick on the sides and base, disc virtually impunctate, sometimes with an evident tubercle medially on each side; elytra extending to the apex of the sixth ventral abdominal segment, sparsely punctured basally becoming finely rugose apically, the tips slightly tumid and finely punctured.

Female: Similar to the male; head narrower than the pronotum, the eyes much smaller and less prominent; antennae extending almost to the tips of the elytra, the intermediate segments about two and a half times as long as wide; elytra extending to the base of the fifth abdominal segment.

Male terminalia: Ventral view; sixth ventral deeply emarginate, the base of the emargination truncate; seventh ventral elongate, slender, sinuate, forked at about the apical fourth, the forks arcuate, divergent throughout their length; last dorsals produced, apex of the penultimate apically emarginate, the side pieces divergent and nearly straight. Lateral view; seventh ventral sinuate, the tips rounded; side pieces of the penultimate dorsal produced ventrad into rather large triangular processes the free angles of which are acute.

Described from Boyer, Oregon, additional specimens have been examined from Little Nestucca River and Peavine Ridge, McMinnville, Oregon, both of these areas being within a forty mile radius of the type locality.

Malthodes intermedius new species

Plate XI; figs. 163, 164

Nigropiceous; head castaneous with the mandibles pale; pronotum yellow with the anterior angles infuscate; basal third of the tibiae testaceous; pubescence cinereous, fine and inconspicuous. Length 3.5 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae, becoming finely scabrose on the neck; eyes large and prominent; antennae moderately slender, segments two and three equal, the fourth evidently longer, intermediate segments about four and a half times as long as wide, the apical segments missing from the unique type; pronotum transverse, the anterior angles rounded and narrowly reflexed, sides concavely subparallel to the hind angles which are prominent, marginal bead fine, disc virtually impunctate; elytra extending to the apex of the fifth abdominal segment, finely rugose punctate, the tips tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; fifth ventral widely shallowly emarginate; sixth ventral slightly narrowed apically, widely deeply emarginate, the base of the emargination truncate; seventh ventral elongate, extending beyond the sixth by slightly less than the length of the sixth, narrowed medially and narrowly forked apically, the base of the furcation rounded, the forks becoming subparallel, the tips acute; produced side pieces of the penultimate dorsal apically incurved, sinuate in outline; ultimate dorsal received in the furcation of the seventh ventral. Lateral view; sixth ventral elongate; seventh ventral apically sinuate, the tips subacute; last dorsals produced, the side pieces of the penultimate narrowly triangularly produced, the free angle of the triangle obtuse.

Holotype, male, Kaweah, California, 7500 feet, Ralph Hopping, in the collection of the California Academy of Sciences.

Malthodes orovillensis new species
Plate XI; figs. 165, 166

Piceotestaceous; the head including the clypeus and mandibles darker; pronotum yellowish with the sides infuscate at the anterior angles; apices of the coxae and bases of the trochanters paler; seventh and the apical emargination of the eighth ventral abdominal segments of the male testaceous; pubescence cinereous, fine and inconspicuous. Length 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes prominent; antennae moderately slender, extending to the tips of the wings in repose, segments two and three equal, the fourth longer, the intermediate segments about four times as long as wide; pronotum strongly transverse, the narrowly reflexed anterior angles obliquely rounded, the sides straight, converging slightly to the hind angles which are obtusely rounded and narrowly reflexed, marginal bead thick, becoming fine on the anterior margin, disc finely sparsely punctured; elytra finely rugose punctate to the tips which are tumid and finely punctate.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination truncately rounded; seventh ventral elongate, extending beyond the sixth by about one and a third times the length of the sixth, forked at the apical third, the base of the furcation sharply rounded, the forks bent, becoming parallel apically, the tips rounded, separated by less

than the width of the base at its widest portion; last dorsals triangularly narrowed apically; side pieces of the penultimate dorsal converging apically, the base stout, narrowing to the middle with the apical half slender. Lateral view; seventh ventral sinuate, the tip becoming horizontal and acute; last dorsal prolonged, side pieces of the penultimate dorsal triangularly descending, the free angle rounded and margined; last dorsal small, ovate.

Holotype, male, Oroville, California, March 13, 1928, on *Ceanothus cuneatus*, H. H. Keiffer, in the collection of the California Academy of Sciences; fourteen *paratypes*, same data as the type but collected from March 13 to April 17, 1928; one *paratype*, Ash Mountain, Tulare County, California, April 19, 1933, Ralph Hopping; one *paratype*, Fallen Leaf Lake, Eldorado County, California, July 3, 1935, F. E. Blaisdell.

MALTHODES VISCERATUS Fall

Plate XI; figs. 167, 168

Malthodes visceratus Fall, Ann. Ent. Soc. Am. 12, 1919, p. 42.

Fuscotestaceous; head black with the mandibles pale, the antennae black basally becoming piceous apically; pronotum yellow with the sides more or less widely infuscate, more evidently so anteriorly; apical margins of the ventral abdominal segments narrowly pale; legs piceous; pubescence cinereous, inconspicuous. Length 2.75 to 3 mm.

Male: Head wider than the pronotum, finely sparsely punctate behind the antennae; eyes small and not prominent; antennae slender, extending beyond the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four and a half times as long as wide; pronotum transverse, the anterior angles rounded, narrowly reflexed, the sides straight, parallel to the hind angles which are obtusely rounded, marginal bead thick, disc finely sparsely punctate; elytra sparsely punctured basally becoming punctate apically.

Female: Similar to the male; head about as wide as the pronotum; intermediate antennal segments about two and a half times as long as wide; sides of the pronotum converging somewhat basally.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination truncate; seventh ventral elongate, extending beyond the sixth by three times the length of the sixth, the sides parallel basally, narrowed beyond the middle, forked at the apical third, base of the furcation rounded, the forks moderately widely separated, curved, the tips converging slightly; last dorsals produced, parallel sided; side pieces of the penultimate dorsal straight, parallel, the tips sinuately beveled towards the inner side. Lateral view; seventh ventral strongly ascending apically to near the apical fourth where it levels, the tips sharply rounded; last dorsals produced and strongly arched; side pieces of the penultimate dorsal triangularly produced ventrad at the apex, margined, the free angle of the triangle sharply rounded, apex of the segment serrately truncate; ultimate dorsal narrow, digitate, the tip received in the fork of the seventh ventral.

Fall's type, a male was collected at Mill Valley, California, March 3, 1907, with additional specimens in his series from Mt. Tamalpais, Green Point (Humboldt County) and Mariposa County, California. Material for this study has been seen from the following California localities: Green Point (Humboldt County) paratype, Suisun, Mt. Tamalpais (Marin County), Pope Valley (Napa County), Mill Valley (Marin County).

Malthodes spinicaudus new species

Plate XI; figs. 169, 170

Piceous; the head black; pronotum yellowish becoming infuscate at the anterior angles; intermediate abdominal segments testaceous; male terminalia brownish testaceous; pubescence cinereous, sparse and inconspicuous. Length 2.5 to 3 mm.

Male: Head wider than the pronotum, finely sparsely granulate behind the antennae; eyes large and prominent; antennae slender, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about five times as long as wide; pronotum strongly transverse, the anterior angles obliquely truncated, the sides feebly sinuately converging to the hind angles which are obtuse, marginal bead moderately thick, disc finely sparsely punctured; elytra finely punctured basally, becoming rugose punctate apically, the tips tumid and finely punctured.

Female: Similar to the male; head as wide as the pronotum, the intermediate antennal segments about three times as long as wide.

Male terminalia: Ventral view; sixth ventral widely moderately deeply emarginate, the base of the emargination rounded and the sides sinuate; seventh ventral prolonged, extending beyond the sixth by about twice the length of the sixth, sinuately narrowed from the base to the apical third where it is forked, the bases of the forks very strongly divergent to the basal third then bent caudad; side pieces of the penultimate dorsal sinuately incurved, the apices closely hugging the sides of the seventh ventral. Lateral view; seventh ventral strongly sinuately ascending from about the middle, the apex leveled, a stout acute spine on the dorsal surface just before the sinuation; last dorsals prolonged, strongly arched; side pieces of the penultimate dorsal triangularly descending from the apical angles, the free angle rounded; ultimate dorsal narrow, digitate, slightly curved and received in the forks of the seventh ventral.

Holotype, male, Fallen Leaf Lake, Eldorado County, California, July 10, 1935, F. E. Blaisdell; *allotype*, female, Huntington Lake, California, July 14, 1919, E. P. VanDuzee, types in the collection of the California Academy of Sciences; *paratypes:* 17, same data as the type but collected from July 3 to July 20, 1935; 1, same data as the allotype but collected June 21, 1915; 6, Lake Tahoe, California, July 10, 1913, Hubbard and Schwarz; 2, Lake Tahoe, California, June 19, 1948, D. J. & J. N. Knull; 7, Chester, California, June 19, 1948, D. J. & J. N. Knull; 1, G. Alpine Creek, Tahoe, California, July 5, 1915, E. P. VanDuzee; 1, Pohono Trail, California, June 18, 1931, E. O Essig; 1, Tallac, California, A. Fenyes.

Malthodes forficatus new species
Plate XII; figs. 171, 172

Fuscous; pronotum yellowish with the margins narrowly infuscate; tips of the elytra obscurely paler; seventh ventral and the middle of the fifth and sixth ventral of the male testaceous; pubescence cinereous. Length 2 to 3.5 mm.

Male: Head wider than the pronotum, finely sparsely granulate behind the antennae; eyes large and prominent, separated frontally by a distance of their own horizontal diameter; antennae slender, extending to the tips of the wings in repose, second and third segments equal, the fourth longer, the intermediate segments about five times as long as wide; pronotum transverse, the sides straight and parallel from the obliquely truncated anterior angles to the broadly rounded hind angles, the anterior margin strongly arched for the reception of the neck, marginal bead thick, disc finely sparsely punctured; elytra with a subsutural row of coarse punctures extending from the base for about one half the elytral length, finely confusedly punctate basally, becoming rugose apically, the tips tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination truncate and the sides sinuate; seventh ventral elongate, narrowed to the apical two fifths where it is forked, the forks slender, widely divergent basally, bent more nearly parallel at the middle, the tips acute. Lateral view; seventh ventral sinuately ascending from the basal third which is rather stout and somewhat descending, the tips acute; last dorsals produced; penultimate dorsal narrow basally, strongly expanded apically where the side pieces descend in subtriangular projections the tips of which are hooked; ultimate dorsal rather large, ovate, apically received in the forks of the seventh ventral; dorsal accessory processes slender, straight, slightly descending.

Holotype, male, Sugar Pine, California, July 5, 1920, E. Schiffer, in the collection of the California Academy of Sciences.

MALTHODES COMPLICATUS Fall
Plate XII; figs. 173, 174

Malthodes complicatus Fall, Ann. Ent. Soc. Am. 12, 1919, p. 40.

Fuscotestaceous; head piceous with the mandibles pale; pronotum clear yellow sometimes narrowly infuscate at the anterior angles; trochanters, apices of coxae and bases of femora paler; male terminalia yellowish; in the female, the intermediate abdominal segments paler apically; pubescence cinereous, sparse and inconspicuous. Length 2.5 to 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes large and prominent; antennae moderately slender, extending to the tips of the wings in repose, segments two and three equal, the fourth evidently longer, the intermediate segments about four and a half times as long as wide; pronotum moderately transverse, the anterior angles rounded, the sides straight and parallel to the hind angles which are feebly

prominent, marginal bead moderately thick, the disc finely sparsely punctured; elytra confusedly punctulate basally becoming rugose towards the apices, the tips tumid and finely punctured.

Female: Similar to the male; head slightly wider than the pronotum, the eyes smaller and not as prominent; antennae extending to about the apical third of the elytra, the intermediate segments about twice as long as wide.

Male terminalia: Ventral view; sixth ventral deeply moderately widely emarginate, the base of the emargination truncate; seventh ventral elongate, extending beyond the sixth by about one and a half times the length of that segment, narrowed from the base to the apical two fifths where it is forked, the base of the furcation acute, the forks curved slightly, the tips acute, separated by about the width of the stem at its widest portion; last dorsals prolonged, dome shaped in outline; ventrally produced side pieces of the penultimate dorsal elongate, acute apically. Lateral view; seventh ventral feebly sinuately ascending apically, the apices sharply rounded; last dorsals produced; penultimate dorsal elongate, the side pieces sharply descending, sickle shaped; ultimate dorsal diagonal, short.

This Californian species was originally recorded from Pomona, Pasadena, Claremont, Santa Barbara and Ojai Valley, California. Additional specimens have been studied from the following California localities: Templeton (San Luis Obispo County), Atascadero (San Luis Obispo County), Keen Camp (Riverside County).

Malthodes blackwelderi new species

Plate XII; figs. 174a, 174b

Castaneous; the mandibles testaceous, antennae and elytra piceotestaceous; pronotum flavous with the anterior angles narrowly infuscate; elytral apices olivaceous; apices of coxae, bases of trochanters and bases and apices of femora and tibiae narrowly pale; male seventh ventral, apical emargination of the sixth and the last dorsals flavous shading to yellowish; pubescence cinereous. Length 3 mm.

Male: Head wider than the pronotum, finely sparsely punctate behind the antennae, becoming granulose on the neck; eyes prominent, separated by about one and a half times their own diameter as viewed frontally; antennae slender, extending beyond the tips of the wings in repose, segments two and three equal, the fourth visibly longer, the intermediate segments about five times as long as wide; pronotum transverse, the anterior angles evenly rounded, narrowly reflexed, the sides sinuate to the hind angles which are prominent and narrowly reflexed, a median longitudinal impressed line extending from the apical margin to near the base, somewhat obliterated medially, marginal bead fine, disc finely sparsely punctured; elytra moderately long, sparsely punctured basally, becoming rugose medially, the tips tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral moderately widely moder-

ately deeply emarginate, the base of the emargination truncately rounded; seventh ventral elongate, extending beyond the sixth by about one and a half times the length of the sixth, narrowing slightly from the base to the apex which is rather shallowly incised, the incision U shaped; last dorsals triangularly produced; side pieces of the penultimate dorsal sigmoidally convergent, the tips hugging the sides of the seventh ventral. Lateral view; seventh ventral arcuately ascending and evenly narrowed from the base to the apex; last dorsals prolonged and arched; side pieces of the penultimate dorsal arising from the apical angles, vertically descending to the middle where they are bent caudad, elongate podiform; ultimate dorsal elongate, apically truncate, a small apical process is digitate.

Holotype, male, Argus Mountains, Death Valley, California, May, 1891 (Koebele), in the collection of the United States National Museum.

This fine species is dedicated to Dr. and Mrs. R. E. Blackwelder, who kindly assisted in making available the museum material for this study.

Malthodes lawrencei new species

Plate XII; figs. 175, 176

Piceous; head black with the front and mandibles pale, the tips of the latter darker; pronotum flavous; trochanters of all legs and tibiae and tarsi of the front legs slightly paler; pubescence cinereous, moderately conspicuous. Length 3 mm.

Male: Head wider than the pronotum, finely sparsely punctate, broadly rather shallowly concave behind the antennae, the concavity extending between the antennae and as a crescent shaped transverse impression behind the antennae thus forming readily visible antennal tubercles; eyes moderately large and prominent; antennae slender, extending beyond the tips of the wings in repose; segments two to four progressively longer, the intermediate segments nearly six times as long as wide; pronotum transverse, the anterior angles rounded and narrowly reflexed, the sides straight, converging slightly to the hind angles which are prominent, marginal bead fine, disc finely sparsely punctate, a lateral ridge arises at each side near the apical third, diagonally extended towards the center for about a quarter of the pronotal width; elytra finely punctate basally, becoming rugose punctate apically.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination truncate; seventh ventral elongate, narrowed from the base to the apical fourth where it is forked, the base of the furcation acute, the forks rather narrowly separated; last dorsal produced, narrowed apically; descending side pieces of the penultimate dorsal apically forked the inner fork the longer, apex of the penultimate dorsal shallowly emarginate. Lateral view; seventh ventral feebly ascending, somewhat narrowed at the apical fourth, the tips acute; sides of the penultimate dorsal produced ventrad at the apical angles, elongate podiform; ultimate dorsal apically truncate.

Holotype, male, Adobe Falls, California, March 8, 1935, A. Watson, in the collection of the California Academy of Sciences.

This species is dedicated to Mr. Fred Lawrence who introduced me to the fascination of studying beetles.

Malthodes eximius new species

Plate XII; figs. 177, 178

Piceous; elytra piceotestaceous; mandibles, male terminalia and sides of the intermediate abdominal segments pale; pubescence cinereous, suberect and moderately conspicuous. Length 3 mm.

Male: Head wider than the pronotum, rather closely finely granulate behind the antennae, especially so on the neck; eyes moderately prominent; antennae stout, extending to a little beyond the elytral apices, segments two to four progressively longer, the intermediate segments about three times as long as wide; pronotum moderately transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides strongly arcuately converging to the hind angles which are very prominent, marginal bead fine, disc finely rather closely granulose; elytra vaguely punctulate basally becoming feebly rugose apically.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral deeply somewhat triangularly emarginate, the base of the emargination rounded; seventh ventral elongate, extending beyond the sixth by about the length of that segment, the sides nearly straight and parallel to the apex which is triangularly notched; last dorsals triangularly produced, the sides of the penultimate dorsal projecting ventrad in the form of digitate processes with a median stem. Lateral view; seventh ventral ascending beyond the middle; last dorsals produced; side pieces of the penultimate dorsal projecting downward then arcuately backward, the sides concentric, the tip truncate; ultimate dorsal large, not prominently produced, rounded beneath.

Holotype, male, Hollister, Idaho, May 20, 1931, D. E. Fox, in the collection of the United States National Museum.

MALTHODES FURCIFER LeConte

Plate XII; figs. 179, 180

Malthodes furcifer LeConte, Trans. Am. Ent. Soc. 9, 1881, pp. 61-62.

Black; pronotum with a small pale spot near the middle of each lateral half; elytral apices obscurely paler; base of emargination of the sixth ventral and basal two thirds of the last dorsal of the male flavous, the seventh ventral griseous; pubescence cinereous, inconspicuous. Length 2 to 3 mm.

Male: Head small, scarcely wider than the pronotum, sparsely granulate behind the antennae, opaque with the granules polished; eyes small and not prominent; antennae stout, extending to the elytral apices, the second and third segments equal, the fourth longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely

rounded and narrowly reflexed, the sides strongly sinuate, converging slightly to the hind angles which are prominent, marginal bead thick, the disc finely minutely granulate; elytra finely punctured basally, becoming feebly rugose punctate apically.

Female: Similar to the male; the head smaller, narrower than the pronotum; antennae extending to about the apical fourth of the elytra, the intermediate segments about three times as long as wide, the last abdominal segments not paler.

Male terminalia: Ventral view; sixth ventral rather narrowly deeply emarginate, the base of the emargination truncate; seventh ventral elongate, extending beyond the sixth by about one and a third times the length of that segment, narrowed to a little beyond the apical third where it is forked, the base of the furcation rounded, the forks curved, becoming parallel apically; last dorsal produced, triangular, the sides sinuate; ventrally produced side pieces of the penultimate dorsal elongate subtriangular. Lateral view; seventh ventral bisinuate, narrowed medially, becoming clavate apically; last dorsals rather feebly produced; side pieces of the penultimate dorsal projected ventrad, the apices formed into stubby pedate processes; ultimate dorsal minute, semicircular.

A topotypical specimen has been studied from Veta Pass, Colorado. Others have been seen from Trujillo and the Blanca Mountains, Colorado.

MALTHODES MACNABI Fender

Plate XIII; figs. 181, 182

Malthodes macnabi Fender, Pan-Pac. Ent. 22, no. 4, 1946, p. 144.

Black; front, mandibles and the apical and basal margins of the pronotum obscurely paler; male terminalia testaceous with the apices of the last dorsals infuscate; apical half of the last dorsal of the female testaceous; pubescence cinereous, fine and inconspicuous. Length 3 to 3.5 mm.

Male: Head slightly wider than the pronotum, finely sparsely punctured behind the antennae; eyes moderately large and prominent; antennae slender, extending to the tip of the abdomen, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides feebly sinuate, converging slightly to the hind angles which are obtuse, marginal bead thick except on the anterior margin where it is fine, disc finely sparsely punctured; elytra long, extending beyond the apex of the sixth abdominal segment, rather closely punctured basally, becoming rugose punctate apically.

Female: Similar to the male; head as wide as the pronotum, the eyes smaller and less prominent; antennae extending to the base of the third abdominal segment, the intermediate segments about two and a half times as long as wide; elytra short, extending to about the base of the second abdominal segment.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate,

the base of the emargination truncate; seventh ventral elongate, slender, extending beyond the sixth by about one and a fourth times the length of that segment, narrowed from the base to the apical third where it is widely forked, the base of the furcation rounded, the forks curved, becoming slightly convergent apically. Lateral view; seventh ventral feebly sinuately ascending, evenly narrowed from the base to the tips which are sharply rounded; last dorsals prolonged, narrowed; side pieces of the penultimate dorsal rather widely projected ventrad in subtrapezoidal plates; ultimate dorsal short, semicircular.

The type series was collected at Lewis Peak, Blue Mountains, Washington. Males of this species have been examined from Durkee, Oregon and Kaslo and Ainsworth, British Columbia.

Malthodes vandykei new species

Plate XIII; figs. 183, 184

Piceotestaceous; head slightly darker with the front and basal two thirds of the mandibles pale; pronotum flavous; scutellum, sides of basal and intermediate abdominal segments and the male terminalia testaceous; pubescence cinereous, fine, short and sparse. Length 3.5 mm.

Male: Head evidently wider than the pronotum, finely sparsely punctured behind the antennae; eyes large and prominent, separated frontally by about one and a half times their own horizontal diameter; antennae slender, extending to the tips of the wings in repose, segments two and three equal, the fourth longer, the intermediate segments about four and a half times as long as wide; pronotum moderately transverse, the anterior angles rounded, the sides feebly sinuate, subparallel to the hind angles which are slightly produced, marginal bead rather thick, the disc finely rather closely granulate; elytra finely rugose, the tips broken off in the type.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral widely deeply trifoliate emarginate, the base of the emargination sharply rounded; seventh ventral narrow, elongate, extending beyond the sixth by about the length of the sixth, narrowed from the base to the apical fifth where it is slightly expanded, the apex triangularly notched, the tips rounded; side pieces of the penultimate dorsal visible as rather long clavate processes. Lateral view; seventh ventral strongly sinuate, ascending apically, becoming thickened at the base of the notch, apically pointed; side pieces of the penultimate dorsal produced diagonly ventrad as rather short spatulate processes.

Holotype, male, Livermore, California, March 31, 1929, E. C. VanDyke, in the collection of the California Academy of Sciences.

Malthodes vanduzeeana new species

Plate XIII; figs. 185, 186

Piceotestaceous; head slightly darker with the apex of the clypeus and the mandibles pale; pronotum flavous with the sides narrowly infuscate at the anterior angles; basal abdominal segment testaceous at the sides; in the male,

the apical emargination of the sixth ventral and basal two thirds of the seventh ventral pale; apical abdominal segments of the female pale; pubescence cinereous, inconspicuous. Length 2.5 to 3.5 mm.

Male: Head slightly wider than the pronotum, finely sparsely punctured behind the antennae; eyes small and not prominent; antennae moderately slender, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum moderately transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides feebly sinuate, converging slightly to the hind angles which are prominent, marginal bead slender, the disc finely sparsely punctured; the elytra finely rugose punctate to the tips which are slightly tumid and finely punctured.

Female: Similar to the male; head as wide as the pronotum; antennae extending to the apical third of the elytra, the intermediate segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination rounded; seventh ventral stout basally, narrowing evenly to the apex which is shallowly notched, the base of the notch and the tips rounded; last dorsals triangular in outline. Lateral view; seventh ventral arcuately ascending, narrowing evenly from the base to the apex which is acute; ventral accessory process similarly curved, digitate; last dorsals prolonged moderately; side pieces of the penultimate dorsal projecting diagonally ventrad from the apical angles, long, digitate, enclosing the seventh ventral.

Holotype, male, *allotype,* female and nine *paratypes,* Livingston Lake, Fresno County, California, 7000 feet, July 9, 1919, E. P. VanDuzee; one *paratype,* Meadow Valley, Plumas County, California, 4000 to 5000 feet, June 1, 1924, E. P. VanDuzee. Types in the collection of the California Academy of Sciences.

The paratype from Meadow Valley is larger than those of the type locality and is slightly darker throughout. The latter condition might be due to the more recent collecting of the specimen, the members of this genus having a tendency to fade with age, especially so if frequently exposed to light.

Malthodes complexipygus new species
Plate XIII; figs. 187, 188

Castaneous; antennae and elytra slightly paler, the elytral apices olivaceous; mandibles and the pronotum flavous; apices of the tibiae of the middle legs narrowly pale; tarsal segments narrowly obscurely annulated; apices of the abdominal segments and the terminalia of the male testaceous, the tip of the seventh ventral infuscate; in the female, the basal abdominal segments pale, the apical segments becoming nearly black; pubescence cinereous. Length 4.5 to 5 mm.

Male: Head wider than the pronotum, finely sparsely granulate behind the antennae; eyes large and prominent, separated frontally by about their own horizontal diameter; antennae very slender, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments almost five and a half times as long as wide; pronotum quadrate, the anterior

angles obliquely truncated and narrowly reflexed, the sides straight, converging slightly to the prominent, rounded hind angles which are more widely reflexed, marginal bead moderately fine, disc virtually impunctate, smooth; elytra sparsely punctured basally, becoming rugose medially, the apices tumid and finely punctured.

Female: Similar to the male; head as wide as the pronotum, the eyes small; pronotum transverse, the sides parallel, the hind angles not prominent.

Male terminalia: Ventral view; sixth ventral deeply triangularly emarginate, the base of the emargination angulate, the sides straight; seventh ventral moderately stout, elongate, extending beyond the sixth by nearly one and a half times the length of that segment, sides evenly sinuate to the apex which is triangularly notched, the tips acute. Lateral view; seventh ventral ascending from near the base, straight and somewhat expanded apically, the tip beveled beneath; last dorsals moderately produced; penultimate dorsal side pieces diagonally descending, spatulate; last dorsal somewhat produced, the undersurface sinuate to the tip which is acute; ventral accessory process elongate, ascending from the base, more rapidly so than the seventh ventral, straight, slightly expanded and subtruncate apically.

Holotype, male and *allotype,* female, Dalton Creek, Fresno County, California, 4800 feet, May 2, 1920, H. Dietrich, in the collection of the New York State College of Agriculture, Cornell University.

Malthodes singularis new species

Plate XIII; figs. 189, 190

Piceotestaceous; head piceous with the mandibles pale; pronotum yellow; apical tumidities of the elytra testaceous; apical margins of the second and third abdominal segments narrowly pale, segments three to six flavous medially; in the male, side pieces of the penultimate dorsal flavous, the seventh ventral flavous basally becoming infuscate apically; last abdominal segments of the female dark; pubescence cinereous, inconspicuous. Length 2.5 to 3 mm.

Male: Head small, slightly wider than the pronotum, finely very sparsely punctured behind the antennae; eyes prominent; antennae slender, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about five times as long as wide; pronotum moderately transverse, the anterior angles rounded, rather widely reflexed, the sides arcuate to the obtusely rounded hind angles which are widely reflexed, marginal bead fine, disc finely sparsely punctured, oblique elongate tumidities extend from near the anterior angles to near the discal center; elytra finely punctured basally, becoming rugose punctate to the tips which are tumid, smooth and very finely punctured.

Female: Similar to the male; eyes smaller, the head just perceptibly wider than the pronotum; antennae extending to the elytral apices, the intermediate segments about three and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral widely, moderately deeply emarginate, the base of the emargination angulately rounded; seventh ventral stout, elongate, extending beyond the sixth by about one and a third times the

length of that segment, forked to nearly the basal third, the base of the furcation acute, the forks parallel for two thirds their length; side pieces of the penultimate dorsal as thin discs, closely hugging the seventh ventral. Lateral view; seventh ventral nearly straight, the forks cultellate; penultimate dorsal short, shallowly emarginate apically, the sides obliquely descending as large ovate processes enclosing the seventh ventral; ultimate dorsal very small, semicircular.

Holotype, male, *allotype*, female and five *paratypes*, Los Angeles County, California. April and May, types in the collection of the California Academy of Sciences. One of the paratypes has the numbers 572 and 33 on the pin and is from the Coquillet collection.

MALTHODES SERICEIVENTRIS Fall

Plate XIII; figs. 191, 192

Malthodes sericeiventris Fall, Ann. Ent. Soc. Am. 12, 1919, p. 40.

Fuscotestaceous; head darker; pronotum flavous; apical tumidities of the elytra olivaceous; sides of basal and intermediate ventral abdominal segments narrowly pale, the intermediate segments having a pale silky appearance; male terminalia flavcus, the apical third of the seventh ventral infuscate; pubescence cinereous. Length 2.5 to 4 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes large and prominent; antennae slender, extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about five times as long as wide; pronotum moderately transverse, the anterior angles narrowly reflexed and obliquely rounded, the sides straight and parallel to the hind angles which are obtuse and a little more widely reflexed, marginal bead fine, the disc finely sparsely puncture, becoming finely granulose near the hind angles; elytra long, extending nearly to the apex of the sixth ventral, sparsely punctured basally, becoming rugose medially, the tips tumid and finely punctured; ventral abdominal segments three to five very finely closely granulose medially which with the pubescence gives them the appearance of being silky, these segments rugose punctate laterally.

Female: Unknown to the author.

Male terminalia: Ventral view; sixth ventral widely emarginate, the emargination extending to the middle of the segment, the base of the emargination rounded; seventh ventral stout, elongate, extending beyond the sixth by a little less than the length of that segment, narrowed from the base to the middle where it is forked, the base of the furcation acute, the forks nearly straight, divergent, the tips rounded; last dorsals triangularly narrowed, the outer sides sinuate. Lateral view; seventh ventral ascending from the middle, the apex beveled beneath; last dorsals not prolonged; side pieces of the penultimate dorsal obliquely descending, expanded apically into large subcircular plates receiving the seventh ventral between them.

At once *sericeiventris* may be separated from the allied species by the pale silky appearance of the median ventral abdominal segments especially as

viewed under low magnification. It was described from Pomona, California. Specimens have been studied from Sierra Madre and Mount Wilson, California.

Malthodes abruptus new species

Plate XIII; figs. 193-195

Piceous; the basal two or three antennal segments and the pronotum with a trace of brunneous; mandibles pale; tarsi and the apices and bases of the femora and tibiae narrowly pale; male abdominal segments testaceous becoming widely infuscate medially, the terminalia flavotestaceous; female darker piceous throughout save for the basal abdominal segments which are paler; pubescence cinereous and inconspicuous. Length 3 to 3.5 mm.

Male: Head slightly wider than the pronotum, feebly rugose just before and between the antennae, finely rather closely granulate behind; eyes moderately large and prominent; antennae rather stout, extending to about half way between the tips of the elytra and the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about three times as long as wide; pronotum transverse, the anterior angles obliquely truncated, rather widely reflexed, the sides straight, converging slightly to the rounded hind angles which are widely reflexed, marginal bead fine, disc finely rather closely granulate, longitudinally impressed medially, a small fovea medially just anterior to the pronotal base; elytra finely rugose to the apices which are feebly tumid and finely punctured.

Female: Similar to the male; the head as wide as the pronotum, eyes smaller; antennae extending to about the apical fifth of the elytra, the intermediate segments about twice as long as wide.

Male terminalia: Ventral view; sixth ventral widely moderately deeply emarginate, the base of the emargination rounded; seventh ventral stout basally, truncate due to the rapid ascension of the apical two thirds, the tips visible as small triangular extensions showing at the sides of the truncation. Lateral view; seventh ventral almost vertically ascending from the basal third, the apical portion sinuate, narrowing to the tips which are acute; last dorsals produced; side pieces of the penultimate dorsal projected strongly ventrad in wide spatuliform processes narrowly enveloping the median portion of the seventh ventral; ultimate dorsal very small, digitate. Caudal view; apical portion of the seventh ventral lyriform, the apex ovately incised, the tips acute.

Holotype, male, *allotype,* female and two *paratypes,* Beaver Canyon, Idaho, July 23, Hubbard and Schwarz, types in the collection of the United States National Museum; one paratype, Fernie, British Columbia, June 5, 1936, H. B. Leech.

Malthodes piperi new species

Plate XIII; figs. 196, 197

Piceous; head black with the mandibles pale; pronotum with an obscure pale spot near the anterior angles; tumidities of the elytral apices olivaceous; abdomen piceotestaceous with the sides and apices of each segment paler; pro-

duced side pieces of the male penultimate dorsal testaceous; pubescence cinereous, sparse and inconspicuous. Length 2.75 to 3 mm.

Male: Head wider than the pronotum, finely sparsely granulate behind the antennae, finely punctured in front; eyes large and prominent; antennae moderately slender, extending to the tips of the wings in repose, segments three and four equal, the second evidently shorter, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides nearly straight, converging slightly to the prominently rounded hind angles which are more widely reflexed, marginal bead thick, becoming finer on the anterior margin, disc finely sparsely granulate; elytra sparsely punctured basally, becoming rugose punctate medially, the apices tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination angulately rounded; seventh ventral elongate, extending beyond the sixth by nearly one and a half times the length of the sixth, moderately stout basally, the sides sinuately narrowing to the apical third which is narrowly forked, the base of the furcation acute, the forks straight and divergent; last dorsals triangularly produced, foliaceous in appearance. Lateral view; seventh ventral strongly ascending from the basal third, the apical two thirds sinuous, evenly narrowing to the tips which are acute; last dorsal feebly produced; side pieces of the penultimate dorsal strongly descending as stout ovate processes nearly enclosing the seventh ventral.

Holotype, male and one male *paratype*, Pullman, Washington, May 15, 1901, C. V. Piper; one *paratype*, Kelso, British Columbia, R. P. Currie; three *paratypes*, Yellow Bay, Flathead Lake, Montana, July 1, 1949; one, Lake McDonald, Glacier National Park, Montana, C. P. Alexander; two, Avalanche Creek, Glacier National Park, Montana, July 4, 1949, C. P. Alexander.

Malthodes acuticaudus new species

Plate XIV; figs. 198, 199

Nigropiceous; head and pronotum black, the mandibles testaceous, becoming infuscate towards the tips; apices of the coxae and bases of the trochanters narrowly pale; male terminalia including the midsection of the sixth ventral flavous, the seventh ventral slightly darker apically; pubescence cinereous, short and sparse. Length 3 mm.

Male: Head as wide as the pronotum, finely sparsely granulose behind the antennae, more closely so on the neck; eyes small, separated frontally by twice their own horizontal diameter; antennae moderately slender, extending to the tips of the seventh ventral, segments two to four progressively longer, the intermediate segments about three and a half times as long as wide; pronotum transverse, the anterior angles obliquely rounded and narrowly reflexed, the sides sinuate, slightly converging to the hind angles which are rounded, marginal bead fine, disc finely sparsely granulose, becoming more closely so towards the sides; elytra long, extending to the apex of the penultimate dorsal, finely sparsely punctured basally, becoming feebly rugose apically, the tips feebly tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the sides of the emargination evenly sinuate, the base rounded; seventh ventral elongate, extending beyond the sixth by a little over one and a half times the length of the sixth, slightly narrowed medially, deeply triangularly notched apically, the base of the notch acute; last dorsals somewhat produced, arcuately narrowed apically; side pieces of the penultimate dorsal subtrapezoidal in shape. Lateral view; seventh ventral unevenly sinuately ascending, the basal curve being much stronger than the apical, side pieces of the penultimate dorsal stout, obovate, strongly descending; ultimate dorsal short, normal.

Holotype, male, Kootenay, British Columbia, June 19, 1948, G. S. Smith, in the collection of the California Academy of Sciences.

Malthodes bakeri new species
Plate XIV; figs. 202, 203

Piceous; head slightly darker, the mandibles paler; pronotum with a large triangular piceotestaceous area at each side; male terminalia flavescent with the apices infuscate; pubescence cinereous, moderately conspicuous. Length 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes small, frontally separated by fully twice their own horizontal diameter; antennae slender, extending to the tip of the abdomen, segments two to four progressively longer, the intermediate segments about three and a half times as long as wide; pronotum transverse, the anterior angles narrowly reflexed and obliquely truncated, the sides sinuate, converging slightly to the hind angles which are obtuse and more widely reflexed, marginal bead thick, becoming finer along the sides and anterior margin, disc finely rather closely granulose; elytra extending to the base of the fourth abdominal segment, rugose punctate throughout, a little more coarsely so apically.

Female: Similar to the male; head narrower than the pronotum; eyes smaller and less prominent; antennae extending to about the apical fourth of the elytra, the intermediate segments about two and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination sharply rounded; seventh ventral elongate, rather stout basally, narrowed to about the apical third where it is forked, the forks divergent, the tips acute, the base of the furcation acute; side pieces of the penultimate dorsal angulately bent in near the middle, the apices closely hugging the seventh ventral at its narrowest portion. Lateral view; seventh ventral sinuately ascending, the tips acute; last dorsals somewhat produced; penultimate dorsal short, oblique with the side pieces subquadrately descending; ultimate dorsal short, spatulate.

Holotype, male, Kootenay Crossing, Kootenay National Forest, British Columbia, July 13, 1949, 3840 feet, J. H. Baker; *allotype,* female, and three *paratypes,* Lake McDonald, Glacier National Park, Montana, no date available, C. P. Alexander; *paratype:* 4, Yellow Bay, Flathead Lake, Montana, July 1, 1949, C. P. Alexander; 2, Twin Creek Camp, Idaho, June 27, 1949, C. P. Alexander: 1, Waterton Lakes, Alberta, July 8, 1949, C. P. Alexander. Types in the collection of the California Academy of Sciences.

Malthodes contortus new species

Plate XIV; figs. 200, 201

Piceous; apical margin of the clypeus and the mandibles pale; pronotum flavous with the sides narrowly and a small median discal spot infuscate; elytra becoming feebly paler beyond the apical third; ventral abdominal segments rather widely pale medially at the apices, more widely so on the second and third; apices of coxae and bases of the trochanters pale; pubescence cinereous, fine and inconspicuous. Length 3 mm.

Male: Head conspicuously wider than the pronotum, finely sparsely granulose behind the antennae; eyes large and prominent, frontally separated by their own horizontal width; antennae moderately slender, extending to the apex of the sixth ventral segment, segments two and three equal, the fourth slightly longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides concave, subparallel to the hind angles which are prominent, marginal bead rather fine, disc finely sparsely punctured; elytra extending to the base of the sixth abdominal segment, finely punctured basally, becoming rugose punctate apically.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral deeply, rather narrowly emarginate, the base of the emargination truncate; seventh ventral elongate, about five times as long as it is wide at the tips, extending beyond the sixth by about one and a half times the length of the sixth, narrowly deeply forked, the forks parallel for two thirds of their length, the base of the furcation angulately rounded; last dorsals triangularly produced; sides of the penultimate dorsal produced, descending, subsecuriform. Lateral view; seventh ventral strongly arcuate, ascending, sinuately leveled apically, the dorsal surface straight and nearly horizontal beyond the apical fifth; last dorsals strongly produced, sides of the penultimate dorsal vertically descending as broad subovate processes, the bases of these processes being similarly broad; ultimate dorsal produced and received in the forks of the seventh ventral.

Holotype, male, McCloud, California, June 28, 1904, A. Fenyes, in the collection of the California Academy of Sciences.

MALTHODES FROSTI Fender

Plate XIV; figs. 204, 205

Malthodes frosti Fender, Pan-Pac. Ent. 19, no. 2, 1943, pp. 67-68.

Piceous; head black with the mandibles obscurely paler; pronotum rufotestaceous to dark brunneous, frequently becoming darker basally, apically and more evidently so at the anterior angles; pubescence cinereous, sparse and inconspicuous. Length 2.5 to 4 mm.

Male: Head wider than the pronotum, finely sparsely punctured; eyes large and prominent; antennae moderately slender, extending to the tips of the abdomen, segments two and three equal, the fourth slightly longer, the intermediate segments about four times as long as wide; pronotum strongly

transverse, the anterior angles rounded, the sides sinuate, converging slightly to the hind angles which are obtusely rounded, marginal bead fine, thicker at the sides, disc finely sparsely punctured; elytra extending to about the apex of the sixth abdominal segment, sparsely punctured basally, becoming feebly rugose apically.

Female: Similar to the male, frequently darker; head as wide as the pronotum, the eyes less prominent; antennae extending to about the apical third of the elytra, the intermediate segments about twice as long as wide.

Male terminalia: Ventral view; sixth ventral rather narrowly deeply emarginate, the base of the emargination truncate; seventh ventral elongate, slender, moderately widely forked at the apical third, the forks becoming parallel apically; side pieces of the penultimate dorsal divergent, the outer margin subsinuate. Lateral view; seventh ventral sinuate, the tips acute; last dorsals prolonged; side pieces of the penultimate dorsal strongly descending into large ovate plates; ultimate dorsal caudally produced as a rather large subquadrate plate.

There is a notable variation in size in this species that seems to be more or less correlated with locality. The smallest specimens were collected at Diamond Lake, Oregon and ranged from 2.5 to 3.5 mm. in length with an average for the series of about 2.75 mm. Series from Hood River Meadows, Bear Springs (Mt. Hood), Still Creek Forest Camp (Mt. Hood) and Elk Lake (North Santiam Highway), Oregon averaged about 3 mm. for each series. The largest specimens were collected along the Metolius River, Oregon and averaged about 3.15 mm. These size variations are quite noticeable when the separated series are placed side by side. Diamond Lake is far to the south of the other localities. The Metolius River area is on the edge of eastern Oregon plateau and at a moderately low elevation. The remaining areas of higher typical northern Oregon Cascades.

Malthodes intricatus new species

Plate XIV; figs. 206, 207

Fuscous; head black with the mandibles pale; elytra fuscopiceous; male terminalia largely testaceous, the sides of the sixth ventral and apex of the last dorsal infuscate; last ventral of the female black to the middle; pubescence cinereous, fine and moderately conspicuous. Length 3 to 4 mm.

Male: Head very slightly wider than the pronotum, finely granulose behind the antennae, becoming scabrose on the neck; eyes moderately large, separated by one and a half times their own horizontal diameter; antennae slender, extending to a little beyond the elytral apices, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum transverse, the sides rather strongly reflexed, sinuate from the rounded anterior angles to the hind angles which are unsually prominent, marginal bead fine, virtually eliminated on the anterior margin, disc finely punctured, a small but evident tubercle medially on each side; elytra extend-

ing to the apex of the fifth abdominal segment, finely rugose punctate, becoming feebly tumid and finely punctured at the tips.

Female: Similar to the male; head narrower than the pronotum, the eyes smaller; antennae extending to the apical third of the elytra, the intermediate segments about two and a half times as long as wide; sides of the pronotum less strongly reflexed and sinuate, the hind angles feebly prominent; pronotal tubercles less prominent and laterally elongate.

Male terminalia: Ventral view; sixth ventral slightly produced, apically expanded. the apex widely deeply emarginate, the base of the emargination truncate; seventh ventral elongate, widely forked at the apical two fifths; side pieces of the penultimate dorsal narrow basally, rapidly expanded at the apical third, the apices sinuately truncate inwardly. Lateral view; sixth ventral produced, subtriangular; seventh ventral sinuate, rather stout basally, narrowing evenly to the tips; last dorsals produced; penultimate dorsal short, diagonal, the side pieces produced ventrad into ovate plates; ultimate dorsal elongate, straight, received in the forks of the seventh ventral.

Holotype, male, Midday Valley, Merritt, British Columbia, June 21, 1924, on *Pinus ponderosa,* no. 17131 lot 1818, K. F. Auden; *allotype,* female, Midday Valley, Merritt, British Columbia, June 17, 1925, no. 17131 lot 36, on *Pinus ponderosa,* Wm. Mathers; *paratypes:* 27, type locality, from June 5 to July 4, 1925 and June 26, 1926; 1, Trinity Valley, British Columbia, July 17, 1938; 2, Waterton Lakes, Alberta, July 8, 1949, C. P. Alexander. Types in the collection of the California Academy of Sciences.

Malthodes idahoensis new species

Plate XIV; figs. 208, 209

Black; mandibles and apical margins of the clypeus narrowly testaceous; elytra becoming paler medially; apices and bases of all femora and tibiae and apices of the coxae and bases of the trochanters narrowly pale; male terminalia flavous with the apices widely infuscate, the base of the emargination of the sixth ventral flavous; pubescence cinereous, sparse and inconspicuous. Length 3 to 3.5 mm.

Male: Head slightly wider than the pronotum, finely sparsely granulate behind the antennae, the interantennal area raised; eyes moderately large and prominent; antennae slender, extending to about the tip of the abdomen, segments two and three equal, the fourth longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles widely reflexed and obliquely truncated, the sides sinuately subparallel to the hind angles which are prominently rounded and widely reflexed, marginal bead thick, the basal portion bordered by a deeply impressed transverse groove, disc finely sparsely punctured, becoming scabrose near the hind angles; elytra sparsely punctured basally, becoming rugose apically.

Female: Similar to the male; head smaller, narrower than the pronotum; antennae extending to about the middle of the elytra, the intermediate segments about twice as long as wide; sides of the pronotum nearly straight, the hind angles obtuse.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate,

the base of the emargination truncate; seventh ventral elongate, stout, forked at about the middle, the forks widely divergent, becoming nearly parallel apically, the tips rounded, the base of the furcation angulately rounded; last dorsals produced; penultimate dorsal sinuately narrowed apically, the descending side pieces apically rotated, the apices sinuate; ultimate dorsal prolonged, conical, the tip truncate. Lateral view; seventh ventral prolonged, sinuate, the tips rounded; last dorsals arched; main body of the penultimate dorsal long, narrow and horizontal, the side pieces produced ventrad from about the basal third of the segment, apically podiform, enveloping the seventh ventral near the apical third of that segment; ultimate dorsal elongate, digitate, strongly descending, received in the forks of the seventh ventral.

Holotype, male; *allotype,* female and one *paratype,* Twin Creek Camp, Idaho, June 29, 1949, C. P. Alexander, in the collection of the California Academy of Sciences.

GROUP XI

1. Tibiae of hind legs of the male apically dilated and with a fringe of long hairs on the posterior side ..... *captiosus*
   Tibiae of hind legs normal in both sexes 2
2. Seventh ventral not forked apically ..... *arcifer*
   Seventh ventral apically forked 3
3. Seventh ventral feebly arcuate in profile, in ventral view the accessory processes slender and sinuate ..... *complexus*
   Seventh ventral either sinuate or medially bent at right angles in profile; accessory processes, if exposed, stout and arcuately converging apically 4
4. Seventh ventral sinuate in profile ..... *sandersoni*
   Seventh ventral rectangular bent up in profile; as viewed caudally, lyre shaped ..... *megapygus*

MALTHODES CAPTIOSUS LeConte

Plate XV; figs. 210-212

Malthodes captiosus LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 61. *Malthodes hirsutotibialis* Fender, Can. Ent. 77, 1945, pp. 38-39.

Head brunneous to black, the front, mandibles and basal antennal segments pale, rest of the antennae piceous; pronotum entirely flavous or with an obscurely darker median discal spot; elytra piceous to piceotestaceous, the apical tumidities yellowish; body beneath flavous, the metasternum and legs a little darker; apices of the male terminalia infuscate; pubescence pale aureous. Length 4 mm.

Male: Head slightly wider than the pronotum, finely tuberculate behind, becoming finely scabrose on the neck; eyes small and not very prominent; antennae moderately stout and unusually long, the apex of the ninth segment extending to the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum moderately transverse, the anterior angles obliquely truncated and narrowly reflexed, the sides strongly sinuate, converging slightly to the hind angles which are prominent and rounded, marginal bead rather thick, disc strongly convex, finely sparsely punctured; elytra extending to the apex of the sixth abdominal segment, finely rugose punctate basally, becoming more coarse-

ly so apically, the tips tumid and finely punctured; tibiae of the hind legs apically dilated, grooved behind with the edges of these grooves adorned with long pale silky hairs.

Female: Similar to the male; head as wide as the pronotum; the antennae extending to the tips of the elytra, the intermediate segments about three times as long as wide; pronotum slightly more transverse, the sides less evidently sinuate; hind legs normal.

Male terminalia: Ventral view; sixth ventral short, narrowly quadrangularly emarginate; seventh ventral elongate, extending beyond the sixth by fully four times the length of that narrow segment, strongly narrowed medially, the apex strongly triangularly emarginate, the tips acute; side pieces of the penultimate dorsal extending beyond the tips of the seventh ventral, arcuately converging apically; lateral spinose processes elongate, sinuate, arising just inside the dorsal side pieces; a secondary short pair of accessory processes lies along side the primary pair and is straight with the tips outwardly beveled. Lateral view; seventh ventral evenly arcuate, the tips acute; side pieces of the penultimate dorsal stout, the dorsal surface suddenly sinuate just beyond the middle, the undersurface shallowly concave; lateral spinose processes arcuately ascending, the tips acute.

LeConte described this species from material collected at Deer Park, Virginia. The author described his *M. hirsutotibialis* from a lone male collected at Black Mountain, North Carolina. In addition to these, specimens have been studied from Highlands, North Carolina and Washington, D. C.

LeConte's description of this species was inaccurate and too brief: "Last ventral slender, forked, piceous, base of antennae, narrow bead of prothorax and base of antennae testaceous; prothorax smooth, a little wider than long, very narrowly margined, anterior and posterior angles impressed; antennae of male nearly as long, of female about one-half as long as the body, second joint two thirds as long as third; male last dorsal segment obtusely rounded, without processes, seventh ventral prolonged into a very slender process, which is strongly curved, and deeply forked with diverging processes at the tip." No mention is made of the dilated and hirsute tibiae of the hind legs. The last dorsal is not obtusely rounded and there are accessory processes. These facts have been verified with the kind help of Floyd Werner who loaned me a male that he carefully compared with the type. Thus *M. hirsutotibialis* Fender becomes a synonym of *M. captiosus* LeConte.

MALTHODES ARCIFER LeConte

Plate XV; figs. 213, 214

Malthodes arcifer LeConte, Trans. Am. Ent. Soc. 9, 1881, p. 62.

Head black, pale in front of the antennae, the basal antennal segment pale; pronotum testaceous, obscurely clouded on the disc and near the anterior angles; elytra piceous; body beneath brunneous; trochanters, apices of the coxae and bases and apices of the femora and tibiae pale (the femora of the front legs entirely pale on some specimens); intermediate ventral abdominal

segments testaceous; pubescence cinereous, fine and sparse. Lngth 3 to 4 mm.

Male: Head rather narrow, scarcely wider than the pronotum, rather finely granulate punctate behind the antennae; eyes moderately prominent; antennae extending to the tips of the wings in repose, segments two to four increasing in length, the intermediate segments about four times as long as wide; pronotum narrowly transverse, the sides sinuately converging from the obliquely truncated anterior angles to the hind angles which are broadly rounded, marginal bead fine, disc finely sparsely punctate; elytra sparsely, rather coarsely punctured basally, becoming rugose apically; anterior tibiae sinuate, slightly enlarged apically.

Female: Similar to the male; the antennae extending only to about the apical third of the elytra, the intermediate segments about two and a half times as long as wide; anterior tibiae not sinuate nor apically enlarged.

Male terminalia: Ventral view; sixth ventral narrowly deeply emarginate, the base of the emargination rounded; seventh ventral elongate, narrowed slightly to the apical third then slightly expanded and rounded into the tip which is not incised; side pieces of the penultimate dorsal strongly produced, slender, strongly incurved apically; long slender dorsal accessory processes spiniform, arising near the base of the prolongation of the penultimate dorsal side pieces; ventral accessory processes short, stout and triangular, arising near the base. Lateral view; seventh ventral straight to the apical third then obliquely ascending to the tip which is sharply rounded; produced side pieces of the penultimate dorsal deflexed somewhat, digitate; dorsal accessory processes long, slender and spiniform, the tips hooked; ventral accessory processes shorter, stouter, similarly hooked at the tips.

Described from Maryland, specimens have been seen from Washington, District of Columbia; Bladensburg, Maryland; Phillipsburg, New Jersey and the following Pennsylvania localities: Pen Mar, Easton, Wind Gap, Mt. Pocono and Stroudsburg.

Malthodes complexus new species

Plate XV; figs. 215-217

Piceous; head darker with the front, mandibles and basal maxillary segment flavous; basal two antennal segment and the third and fourth segments beneath flavous; anterior angles and the basal margin of the pronotum narrowly, the basal angles widely testaceous; elytra piceous, becoming piceotestaceous medially; femora and tibiae of the front and middle legs and bases and apices of the femora and tibiae of the hind legs brownish testaceous; pubescence cinereous, fine and rather conspicuous, recumbent. Length 3.5 mm.

Male: Head slightly wider than the pronotum, finely punctured in front, becoming scabrose on the neck; eyes large and prominent; separated by one and a half times their diameter as viewed frontally; antennae moderately stout, extending to the tips of the wings in repose, segments two to four nearly equal, the fifth evidently longer, the intermediate segments about three and a half times as long as wide; pronotum moderately transverse, deeply deflexed towards the sides anteriorly, the anterior angles rounded and narrow-

ly reflexed, sides widely reflexed, marginal bead thick, becoming finer on the anterior margin, disc finely sparsely punctured; elytra extending to the apex of the fifth abdominal segment, sparsely punctured, basally, becoming rugose apically.

Female: Similar to the male; antennae extending to about the tips of the elytra, the intermediate segments about three times as long as wide.

Male terminalia: Ventral view; sixth ventral deeply moderately widely emarginate, the base of the emargination truncate; seventh ventral elongate extending beyond the sixth by about twice the length of that segment, slender basally, expanding slightly to about the middle then narrowing to the apical third where it is forked, the forks straight and divergent, base of the furcation acute; side pieces of the penultimate dorsal prolonged, slender, apically incurved so that the tips meet; dorsal accessory processes long, spiniform, the tips sinuately incurved; ventral accessory processes stout basally with two finger like extensions arising at the apex, the inner angle dentate. Lateral view; seventh ventral slightly arcuately ascending, the apex beveled beneath; penultimate dorsal prolonged, the side pieces still further prolonged, narrow, the apices subovate; ultimate dorsal elongate, spatulate with the apex truncate; dorsal accessory processes strongly ascending from near the base, elongate ovate.

Holotype, male and *allotype,* female, Graybeard, North Carolina, June 25, in the collection of the American Museum of Natural History. *Paratypes:* 10, same as the types but collected June 16 to 25; 1, Linville, North Carolina, June 26, 1941, R. C. Barnes; 15, Black Mountains, North Carolina, June and July, 1902, E. C. VanDyke.

Malthodes sandersoni new species

Plate XV; figs. 218, 219

Nigropiceous; apex of the clypeus, mandibles, basal segments of maxillary palpi, basal two segments of the antennae and margins of the pronotum testaceous; coxae, trochanters and tibiae of the front and middle legs testaceous; base of the seventh and apices of the penultimate dorsal of the males flavous with the rest of the abdomen piceotestaceous; in the female, the median segments of the abdomen piceotestaceous, the apical segments piceous; pubescence cinereous, moderately conspicuous. Length 3.5 to 5 mm.

Male: Head as wide as the pronotum, the eyes small and not prominent; antennal sockets angulately protuberant, the interantennal area rather strongly concave, surface rather strongly, sparsely granulate; antennae stout, extending to the tips of the wings in repose, segments two and three equal, the fourth evidently longer, the intermediate segments about three times as long as wide; pronotum subquadrate, the anterior angles strongly reflexed and obliquely truncated, the sides sinuate, converging slightly to the obtusely rounded hind angles which are strongly reflexed, marginal bead fine on the anterior and posterior margins, thicker at the sides, disc finely sparsely punctured, tumidly expanded laterally between the reflexed front and hind angles; elytra extending to the apical margin of the fifth abdominal segment, vaguely punctulate

basally, feebly rugulose to about the apical third where they become finely scabrose, the tips tumid and finely punctured.

Female: Similar to the male; eyes smaller, the head narrower than the pronotum, more coarsely granulose, becoming rugulose between and just behind the antennae; antennae extending to about the tips of the elytra, the intermediate segments about two and a half times as long as wide; pronotal pale areas usually confined to the angles; front and middle legs flavous with the tarsi infuscate, the hind legs with the tarsi and apical half of the tibiae fuscous.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination truncate; seventh ventral elongate extending beyond the sixth by nearly twice the length of that segment, narrowed medially, the apex forked, the forks straight and divergent; side pieces of the penultimate dorsal produced caudad, triangular in cross section, the apices triangularly expanded; ventral accessory processes not exposed; dorsal accessory processes arising near the sides, strongly spirally in-curved apically, with a small protuberance on the outer side near the apex; a semi-opaque internal process inside the spiral of the dorsal accessories. Lateral view; seventh ventral strongly arcuately ascending, expanded near the apical third then evenly narrowed to the sharply rounded tip; caudally produced side pieces of the penultimate dorsal apically deflexed, the apices rather widely beveled beneath, receiving the seventh ventral between them; ventral accessory processes narrow and apically hooked; dorsal accessory processes stout, sinuately descending.

Holotype, male, Pine Heath, Gatlinburg, Great Smoky Mountain National Park, Tennessee, 3500 feet, July 8, 1947, R. H. Whittaker; *allotype,* female, same data as type but collected June 19, 1947; *paratypes:* 18, same general locality at the following specific areas (apparently ecological); Pine Heath, 3500 feet, June 19 to July 8; Beech Gap, 5500 feet, June 23; Oak-Chestnut, 2700 feet, July 21; Hemlock Forest, 4000 feet, June 29. The types in the collection of the Illinois Natural History Survey.

Malthodes megapygus new species

Plate XV; figs. 220-222

Head black behind and castaneous between the antennae, shading gradually to flavous on the mandibles and clypeus; antennae mahogany, the second segment paler and the basal segment flavous; pronotum and scutellum flavous; elytra dark mahogany with the tips olivaceous; body beneath flavous with the metasternum mahogany and the tips of the male terminalia infuscate; legs dark flavous beneath, becoming brunneous above; pubescence aureous. Length 4 mm.

Male: Head wider than the pronotum, finely granulate behind the antennae; eyes small and not very prominent; antennae stout, extending to the apices of the wings in repose, segments two to four progressively longer, the intermediate segments about four and a half times as long as wide; pronotum moderately transverse, the anterior angles rounded, sides sinuate, converging slightly to the hind angles which are quite prominent, sides rather sharply but narrowly reflexed, more widely so at the anterior angles, marginal bead fine,

disc virtually impunctate; elytra punctured basally, becoming finely rugose punctate apically, pubescence suberect.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral deeply emarginate, the base of the emargination rounded, the sides concavely rounded; seventh ventral elongate, about two and a half times as long as wide, seemingly truncated apically due to the rectangular bending of the segment leaving the apex concealed; penultimate dorsal deeply forked, the side pieces large and stout, apically incurved and subclavate. As viewed posteriorly; apex of the seventh ventral lyre shaped, forked, the tips acute. Lateral view; seventh ventral stout and evenly curved to about the apical third where it is rectangularly ascending and suddenly constricted into a thin plate, the outer face of this plate concave; penultimate dorsal side pieces stout, produced, strongly arched, the apices clavate; ultimate dorsal concealed; dorsal accessory process short, triangular with the free angle rounded.

Holotype, male, Scioto County, Ohio, June 10, 1944, D. J. & J. N. Knull, in the Knull collection.

GROUP XII

1. Last dorsals not appreciably produced, shorter than seventh ventral; accessory processes less evident, the lateral spinose processes absent 2
   Last dorsals more strongly produced, extending nearly as far as or farther than the seventh ventral; ventral accessory process one half or more as long as seventh ventral; lateral spinose processes present (except in *magister*) 3
2. In profile, seventh ventral straight, ultimate dorsal rectangularly bent ventrad ..... *californicus*
   In profile, seventh ventral arcuately ascending; last dorsals normal ..... *ovatus*
3. Seventh ventral arcuate in profile 4
   Seventh ventral sinuate in profile 6
4. Lateral spinose processes concealed or absent; ventral accessory process strongly arcuately ascending, the tip nearly touching the dorsal accessories ..... *magister*
   Lateral spinose processes present; ventral accessory process less strongly ascending, the tip not nearly touching the dorsal accessory processes 5
5. Lateral spines incurved apically; pronotum fulvotestaceous, the disc with a large brunneous spot on each side of the middle ..... *profusus*
   Lateral spines outcurved apically; pronotum piceous ..... *evexus*
6. Seventh ventral emarginate at the tip ..... *canadensis*
   Seventh ventral subtruncate or rounded at the tip 7
7. Seventh ventral truncate at the tip; ventral accessory process not apically dilated, extending to about the apical fourth of the seventh ventral which is straight basally, the apical half sinuate; dorsal accessory processes ovate, pronotum dark with the margins narrowly pale ..... *ute*
   Seventh ventral narrowing apically, the tip rounded; ventral accessory process apically dilated, extending to about the middle of the seventh ventral which is evenly sinuate; dorsal accessory processes subrectangular; pronotum fulvotestaceous with a blackish discal spot ..... *dorothae*

Malthodes californicus new species

Plate XVI; figs. 223, 224

Piceotestaceous; head slightly darker behind the antennae; pronotum yellow; sides and apices of the ventral abdominal segments rather widely pale; pubescence cinereous, short and somewhat conspicuous. Length 2.75 mm.

Male: Head wider than the pronotum finely sparsely punctured behind the antennae; eyes moderately large and prominent; antennae slender, extending to the tips of the wings in repose, segments two and three equal, the fourth visibly longer, the intermediate segments about four times as long as wide; pronotum transverse, the anterior angles obliquely rounded, the sides straight, converging slightly to the hind angles which are prominent, all angles reflexed, the posterior widely so, marginal bead thick, disc finely sparsely punctured; elytra extending to the apex of the fourth abdominal segment, finely rugose punctate throughout.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral narrowed apically, the apex widely deeply emarginate, the base of the emargination rounded; seventh ventral stout, spatulate, the sides parallel to the evenly rounded tip. Lateral view; seventh ventral straight, narrowed apically, last dorsals not appreciably produced, the ultimate dorsal slightly extended, rectangularly bent down; accessory dorsal process arising near the apical angles of the penultimate dorsal, subovate with the tip slightly produced and truncate.

Holotype, male, Los Angeles County, California, June, Coquillet, in the collection of the California Academy of Sciences.

Malthodes ovatus new species

Plate XVI; figs. 225, 226

Piceous; head slightly darker, the mandibles pale; pronotum flavous; basal two antennal segments and tibiae of the front legs testaceous; elytral apices, tibiae of middle and hind legs and bases and apices of all femora piceotestaceous; pubescence cinereous, fine and sparse. Length 3 mm.

Male: Head slightly wider than the pronotum, finely sparsely punctured behind the antennae; eyes moderately large and prominent; antennae moderately slender, extending to slightly short of the elytral apices, segments two and three equal, the fourth conspicuously longer, the intermediate segments about three times as long as wide; pronotum moderately transverse, widest at about the apical third, anterior angles rounded, the sides arcuate, converging slightly to the hind angles which are prominent, marginal bead very fine, disc finely sparsely punctured; elytra finely rugose basally, becoming scabrose medially, the tips tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral small, narrow, narrowly deeply emarginate, the base of the emargination rounded; seventh ventral elongate oval. Lateral view; sixth ventral small; seventh ventral short, thin, arcuately ascending apically; last dorsals large, otherwise normal.

Holotype, male, Los Gatos, California, in the collection of the United States National Museum.

This specimen was tentatively labeled *ligulifer* with a question mark. The flavous pronotum immediately removes the specimen from Bergroth's species which is most unsatisfactorily described.

MALTHODES MAGISTER Fall
Plate XVI; figs. 227-230

Malthodes magister Fall, Ann. Ent. Soc. Am. 12, no. 1, 1919, p. 35.

Piceotestaceous; head darker; pronotum fulvotestaceous, either with or without a blackish discal spot; antennae and legs fuscous; elytral apices testaceous; pubescence cinereous, sparse and inconspicuous. Length 5 to 5.6 mm.

Male: Head moderately wider than the pronotum, finely rather closely granulate behind the antennae; eyes moderately prominent; antennae extending to the tips of the abdomen, segments two to four progressively longer, the intermediate segments about four times as long as wide; pronotum subquadrate, the anterior angles obliquely rounded and reflexed, the sides strongly deflexed, concavely converging slightly to the prominently rounded and widely but shallowly reflexed hind angles, marginal bead fine, becoming thicker at the hind angles, disc finely sparsely punctured; elytra extending to the base of the sixth abdominal segment, finely rugose to the apices which are feebly tumid and finely granulate.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral deeply, broadly emarginate, the base of the emargination rounded; seventh ventral elongate, extending beyond the sixth by about the length of the sixth, gradually narrowed to the evenly rounded apex; sides of the ventral accessory process widened apically, shallowly emarginate at the tip; last dorsals narrowly triangularly produced slightly beyond the seventh ventral, rounded at the tip. Lateral view; seventh ventral arcuate, slender; last dorsals produced, otherwise normal; ventral accessory process strongly ascending, virtually attaining the dorsal accessory processes; dorsal accessory processes partially concealed, elongate ovate, sparsely clothed with rather long fine hairs.

Fall's type is from Blair's Ranch, Redwood Creek, Humboldt County, California, September 6, H. S. Barber. It has a rather well developed discal black spot on the pronotum. A second specimen, cited by Fall, is from Green Point, Humboldt County, California, June 4, 1916, F. E. Blaisdell. The latter specimen has been made available through the kindness of the staff of the California Academy of Sciences and from this specimen this description has been drawn. It differs from the type in that the pronotal spot is virtually obsolete.

Malthodes profusus new species
Plate XVI; figs. 231-235

Piceotestaceous; head black with the front, mandibles and basal palpal segments testaceous, basal two or three antennal segments somewhat paler; pronotum fulvotestaceous, a large brunneous spot on the middle of each side of the disc; trochanters, apices of the coxae, bases and apices of the femora and bases of the tibiae of the front and middle legs testaceous; sides and apices of the ventral abdominal segments narrowly testaceous; male terminalia, save for the black lateral spines, testaceous; pubescence cinereous, fine and sparse. Length 3 to 3.25 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes moderately large and prominent; antennae slender, extending beyond the tips of the wings in repose by at least the last segment, segments three and four equal, the second evidently shorter, the intermediate segments about four and a half times as long as wide; pronotum subquadrate, the anterior angles obliquely truncated and feebly explanate, the sides concave, converging slightly to the hind angles which are prominent, marginal bead fine, disc finely sparsely granulate with a low tumidity medially on each side; elytra extending to the apex of the fifth abdominal segment, finely rugose throughout.

Female: Similar to the male; pronotal brown spots much reduced; head as wide as the pronotum; eyes smaller, less prominent; intermediate antennal segments about two and a half times as long as wide; pronotum transverse, the anterior angles rounded, the sides feebly concave; elytra extending to the apex of the fourth abdominal segment.

Male terminalia: Ventral view; sixth ventral widely deeply emarginate, the base of the emargination rounded; seventh ventral stout, elongate, extending beyond the sixth by about the length of the sixth, spatulate in shape, the tip evenly rounded; lateral spinose processes strongly hooked inwardly at the tips. Lateral view; seventh ventral evenly arcuately ascending; ventral accessory process elongate, slightly expanding apically, apically truncate, the apex of this process triangularly emarginate at the middle, the sides angulately produced; lateral spinose processes stout basally, the tips bent down, acute; dorsal accessory processes spoon shaped; last dorsal not produced beyond the seventh ventral.

Holotype, male and *allotype* female, Mt. Timpanogos, Utah, July 26, 1945, G. F. Knowlton, in the collection of the United States National Museum.

Malthodes evexus new species

Plate XVI; figs. 236-240

Piceous; head black with the mandibles pale; elytral tips olivaceous; segments of the legs narrowly obscurely paler at the joints; sides of the basal three ventral abdominal segments and apical angles of segments four to six pale; seventh ventral, apex of the penultimate dorsal and accessory processes, excepting black spinose lateral processes, fuscous; pubescence cinereous, inconspicuous. Length 3.5 mm.

Male: Head evidently wider than the pronotum, very finely sparsely granulate behind the antennae; eyes moderately large and prominent; antennae moderately stout, extending to about the tips of the wings in repose, segments two to four progressively longer, the intermediate segments about four and a half times as long as wide; pronotum moderately transverse, the anterior angles obliquely truncated, prominent laterally, the sides concave, converging slightly to the hind angles which are prominent, marginal bead fine, disc finely sparsely punctured; elytra sparsely punctured basally, becoming finely rugose punctate apically.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral slightly narrowed apically, widely deeply emarginate, the base of the emargination evenly rounded; seventh ventral elongate, stout, extending beyond the sixth by about the length of the sixth, spatulate shaped, the apex evenly rounded; lateral spinose processes extending to about the apex of the sixth ventral, turned out at the tips. Lateral view; seventh ventral evenly arcuately ascending apically; ultimate dorsal comparatively large, extending slightly beyond the tip of the seventh ventral, oblong ovate with the tip pointed; dorsal accessory processes similar to the ultimate dorsal, clothed with long fine hairs; ventral accessory process subquadrate, the apex rather deeply emarginate, the base of the emargination acute, the sides curved up at the apical angles giving the segment the appearance of being clavate in profile.

Holotype, male, and one *paratype*, Grand Teton National Park, Wyoming, July 14, 1939, D. J. & J. N. Knull. One *paratype*, Gallatin County, Montana, July 25, Hubbard and Schwarz. Type in the Knull collection.

Malthodes canadensis new species
Plate XVII; figs. 241-245

Piceous; head black behind, the front and bases of the mandibles pale; basal and apical margins of the pronotum narrowly pale; elytral apices piceo-testaceous; sides and apices of the ventral abdominal segments narrowly pale, the seventh ventral and accessory processes of the male testaceous, the lateral spines black; pubescence cinereous, fine and sparse. Length 3 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind the antennae; eyes moderately large and prominent; antennae stout basally, becoming slender apically, extending to the tips of the wings in repose, segments two to four increasing in length, the intermediate segments about three and a half times as long as wide, those beyond the third subserrate; pronotum moderately transverse, the anterior angles obliquely truncated, the sides concave, converging slightly to the hind angles which are prominent, marginal bead thick, obliterated at the sides, disc finely, very sparsely granulate; elytra fairly short, extending to the base of the fourth abdominal segment, finely punctured basally, becoming rugose to the tips which are tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral slightly narrowed apically, the apex widely deeply emarginate, the base of the emargination rounded; seventh ventral stout; subspatulate, the tip shallowly arcuately emarginate; lateral spinose processes slender, apically curved out; ventral accessory process apically expanded, narrowly triangularly notched at the apex. Lateral view; seventh ventral arcuately ascending, becoming sinuate near the apex; ventral accessory process elongate, slightly expanded apically, the tip somewhat beveled beneath; lateral spinose processes moderately stout basally, evenly narrowing to the tip which is acute, sinuate; dorsal accessory processes oblong oval, the tip slightly produced and acute, clothed with fine long hairs; last dorsals produced slightly beyond the seventh ventral.

Holotype, male, Trinity Valley, British Columbia, July 7, 1928, H. A. Richmond, in the collection of the California Academy of Sciences. *Paratypes:* 1, Baker Lake, Mt. Baker, Washington,, July 14, 1948, C. P. Alexander; 1, Marymere Falls, Barnes Creek, Lake Crescent, Washington, July 20, 1948, C. P. Alexander; 1, Olympic Hot Springs, Olympic Mountains, Washington, July 17, 1948, C. P. Alexander; 2, Lorna, British Columbia, July 3 & 11, 1924, on *Abies laciocarpa,* Hopping collection; 2, Midday Valley, British Columbia, July 17 & 29, 1925, on *Pinus ponderosa,* Hopping collection.

Malthodes ute new species

Plate XVII; figs. 231-235

Fuscotestaceous; head somewhat darker, paler in front of the antennae; pronotal margins narrowly paler; sides and apices of the ventral abdominal segments two to four widely testaceous, the fifth pale medially, becoming darker towards the sides; male terminalia testaceous, the lateral spinose processes blackish; pubescence cinereous, sparse and inconspicuous. Length 3 mm.

Male: Head wider than the pronotum, rather coarsely granulate behind the antennae; eyes large and prominent; antennal tubercles evident, the interantennal area strongly concave, antennae broken in the type; pronotum subquadrate, the anterior angles rounded, laterally prominent, the sides concave, converging slightly to the hind angles which are rounded, side margins strongly deflexed, scarcely visible from a dorsal view, disc strongly convex, finely sparsely punctured; elytra sparsely rather coarsely punctured basally, becoming rugose medially, the tips tumid and finely punctured.

Female: Unknown.

Male terminalia: Ventral view; sixth ventral short, widely deeply emarginate, the emargination evenly rounded; seventh ventral strongly bent up at the middle, the tip leveling slightly; ventral accessory process parallel sided, the apex very shallowly arcuately emarginate; lateral spinose processes straight, narrow. Lateral view; seventh ventral strongly bent up at the middle, the apical half sinuate; last dorsals produced beyond the tip of the seventh ventral; penultimate dorsal large, otherwise normal; ventral accessory process strongly ascending apically, the tip rounded; dorsal accessory processes oblong oval, the tip slightly produced and acute; lateral spinose processes stout, truncate apically.

Holotype, male, Daniels Canyon, Heber, Utah, July 5, 1922, E. P. VanDuzee, in the collection of the California Academy of Sciences.

Malthodes dorothae new species

Plate XVII; figs. 251-255

Piceous; head and antennae black, apical half of the front and the mandibles fulvotestaceous; pronotum fulvotestaceous with a blackish discal spot; apices of the coxae, bases of the trochanters and the apices of the tibiae narrowly pale; in the male, seventh ventral and the apical two thirds of the penultimate dorsal flavous; pubescence cinereous, moderately conspicuous. Length 4 to 4.5 mm.

Male: Head distinctly wider than the pronotum, coarsely rather closely granulose behind the antennae; eyes large and prominent; antennae stout, extending to near the tips of the wings in repose, segments two to four increasing in length, the intermediate segments about four and a half times as long as wide; pronotum moderately transverse, the anterior angles evenly rounded and laterally produced, the sides straight, converging slightly to the hind angles which are prominent, marginal bead thick, becoming obliterated along the sides, disc finely sparsely punctured; elytra finely rugose punctate basally becoming rather coarsely rugose apically.

Female: Similar to the male; head smaller, slightly wider than the pronotum; eyes smaller and less prominent; antennae extending to about the elytral apices, the intermediate segments about three and a half times as long as wide.

Male terminalia: Ventral view; sixth ventral constricted apically deeply rather narrowly emarginate, the base of the emargination broadly rounded; seventh ventral elongate, twice the length of the sixth, the sides parallel to the middle then narrowed slightly to the tip which is subtruncately rounded; ventral accessory process apically expanded, the apex triangularly notched at the middle; lateral spinose processes straight, slender. Lateral view; seventh ventral evenly sinuate, the tip rounded; last dorsals produced slightly beyond the tip of the seventh ventral; ultimate dorsal securiform; ventral accessory process rather short, becoming subtriangular apically; dorsal accessory processes subrectangular, produced slightly beyond the tip of the ventral accessory; lateral spinose processes stout to the apex which is sharply deflexed, the tip bluntly pointed.

Holotype, male, Hubbard, Oregon, July 2, 1944, D. McKey-Fender; *allotype,* female, Wilson River, near Creston, Oregon, July 7, 1945, K. M. Fender. *Paratypes:* 1, same data as allotype; 1, Government Camp, Mount Hood, Oregon, July 5, 1942; 1, Bover, Oregon, May 24, 1936, K. M. Fender; 4, Silver Creek Falls, Oregon, August 2, 1948, Alexander and Fender; 14, Salt Creek Falls, Willamette Pass, Oregon, August 7, 1948, Alexander and Fender; 1, Stevens Pass, Washington, July 8, 1948, C. P. Alexander.

Addenda

The following species was set aside for further study then inadvertently overlooked until the study was virtually completed when a final check up revealed the oversight.

Malthodes provoensis new species

Head castaneous, flavous in front of the eyes; antennae piceous, the basal two segments flavous; pronotum yellow, the anterior angles narrowly infuscate; elytra piceous with the median third becoming testaceous; body beneath piceotestaceous, becoming paler at the sutures; ventral abdominal segments flavous, the margins rather widely paler; legs piceous, the coxae, trochanters, apices and bases of the femora and tibiae testaceous; pubescence cinereous, fine, sparse and suberect. Length 2.5 to 2.75 mm.

Male: Head wider than the pronotum, finely sparsely punctured behind

the antennae; eyes moderately large and prominent; antennae moderately slender, extending to the tips of the wings in repose, segments two to four increasing in length, the intermediate segments about three and a half times as long as wide; pronotum moderately transverse, the anterior angles obliquely truncated, the sides straight, converging slightly to the hind angles which are prominent, marginal bead fine, disc finely sparsely granulate; elytra extending to the base of the fourth abdominal segment, finely sparsely punctured basally, becoming finely rugose apically.

Female: Similar to the male; head smaller, narrower than the pronotum; eyes smaller and less prominent; antennae extending to slightly beyond the elytral apices, the intermediate segments about three times as long as wide; pronotum with a small median dark spot, the anterior angles more widely infuscate, the sides less strongly convergent to the hind angles which are obtuse.

Male terminalia: Ventral view; sixth ventral small, apically narrowed, moderately widely deeply emarginate, the base of the emargination sharply rounded; seventh ventral stout, elongate, extending beyond the sixth by about the length of the sixth, arcuately narrowed apically, broadly triangularly emarginate, the tips angulate. Lateral view; seventh ventral straight, the tip rounded; last dorsals normal.

Holotype, male; *allotype,* female and six *paratypes,* Provo, Utah, June, Wickham. Types in the collection of the Museum of Comparative Zoology.

Close to *M. pictus* from which it differs in having the pronotal disc unornamented in the male and the basal two antennal segments pale. The apical notch of the male seventh ventral is more broadly triangular than in *M. pictus.*

Unrecognizable Species

MALTHODES FULVICOLLIS Kiesenwetter

For some reason, probably on the basis of the pronotal coloration, Leng placed this name as a synonym of *M. exilis.* Kiesenwetter's description indicates a species from Massachusetts in which the seventh ventral is forked at the middle with the forks divergent or gable shaped. *M. fuliginosus* var. *flavicollis* more closely fits this description than does any other known to occur in or near Massachusetts. Kiesenwetter's definition of his species is scarcely accurate enough to definitely place his species as the *M. fuliginosus* variety, so his species must be included with those species unrecognized by the author.

LeConte described three species from females that have never been accurately or satisfactorily fitted with any known male. The descriptions of these females follow.

MALTHODES ANALIS LeConte

Malthodes analis LeConte, Trans. Am. Ent. Soc. 11, 1881, p. 62.

Head black, convex, densely punctulate, eyes small; antennae slender, extending to end of elytra piceous, joints 2-4 nearly equal, first joint yellow. Prothorax bright yellow, not wider than long, transversely convex, sides narrowly margined, front angles obliquely truncate. Scutel and elytra piceous,

finely rugosely punctured as usual, half as long as the abdomen; abdomen yellow with last two dorsal and ventral segments black; metasternum dusky, legs yellow, partly dusky. Length 4 mm.; middle states; one female.

MALTHODES CONGRUUS LeConte

Malthodes congruus LeConte, Trans. Am. Ent. Soc. 11, 1881, p. 62.

Dusky, prothorax fuscotestaceous, one half wider than long, sides parallel, strongly margined, head densely punctulate, darker piceous, occiput feebly channeled, eyes small, antennae stout reaching to the middle of the elytra, joints 2-4 nearly equal. Elytra nearly as long as the abdomen, three fourths as long as the wings, finely rugosely punctured. Differs from *fragilis* by sides of prothorax straighter and angles better defined. Length 2.5 mm.; Va.; one female.

MALTHODES QUADRICOLLIS LeConte

Malthodes quadricollis LeConte, Trans. Am. Ent. Soc. 11, 1881, p. 63.

Dusky, head blackish, larger, wider than prothorax, densely punctulate, eyes larger and more prominent; prothorax not wider than long, dull yellow, sides parallel, strongly margined, broadly impressed near the front angles, antennae rather stout, extending beyond the middle of the elytra, first joint testaceous, 2-4 nearly equal. Elytra two thirds as long as the wings, rugosely punctured. Differs from *fragilis* and *exilis* by prothorax not wider than long. Length 2.5 mm.; Lake Superior; one female.

MALTHODES LIGULIFER Bergroth

Malthodes ligulifer Bergroth, Bull. Soc. Ent. France, 1889, p. 203.

Bergroth's description unfortunately has not been seen. Of this species, Fall says: ". . . *M. ligulifer* described by Bergroth from Monterey, California, and said to be related by its male sexual characters to *spado* LeC. The prothorax of *ligulifer* is said to be 'nigro-piceus, anguste luteo-circumlimbatus' which doesn't apply normally to any California species known to me, and is only approached by some forms of *basalis* near which it may be listed for the present; the terminal ventral segments of the male are, however, not defined with sufficient exactness to enable me to include it in the following table." The species apparently belongs in group I of *Malthodes*. An examination of the type would most certainly be required to satisfactorily place the species.

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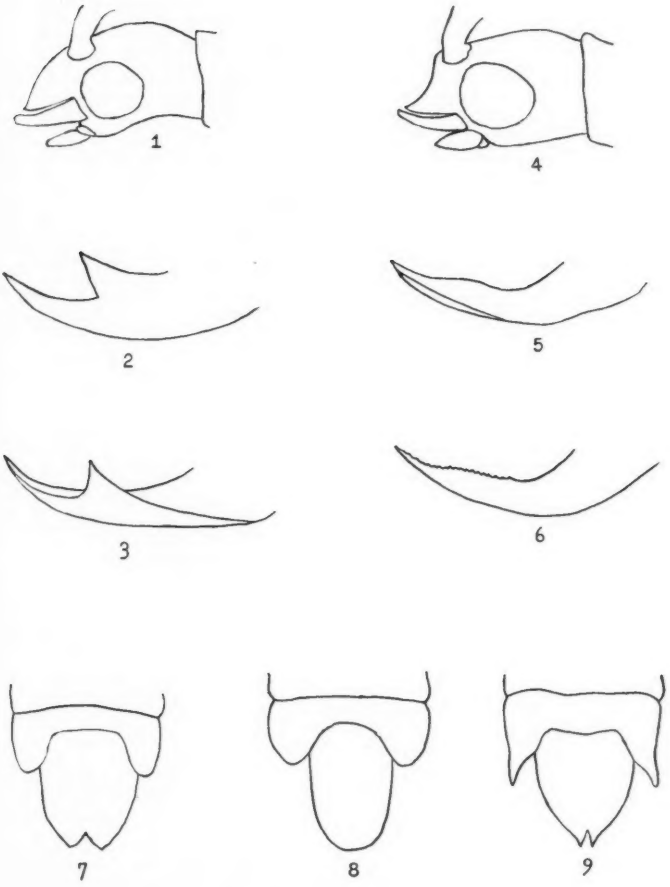

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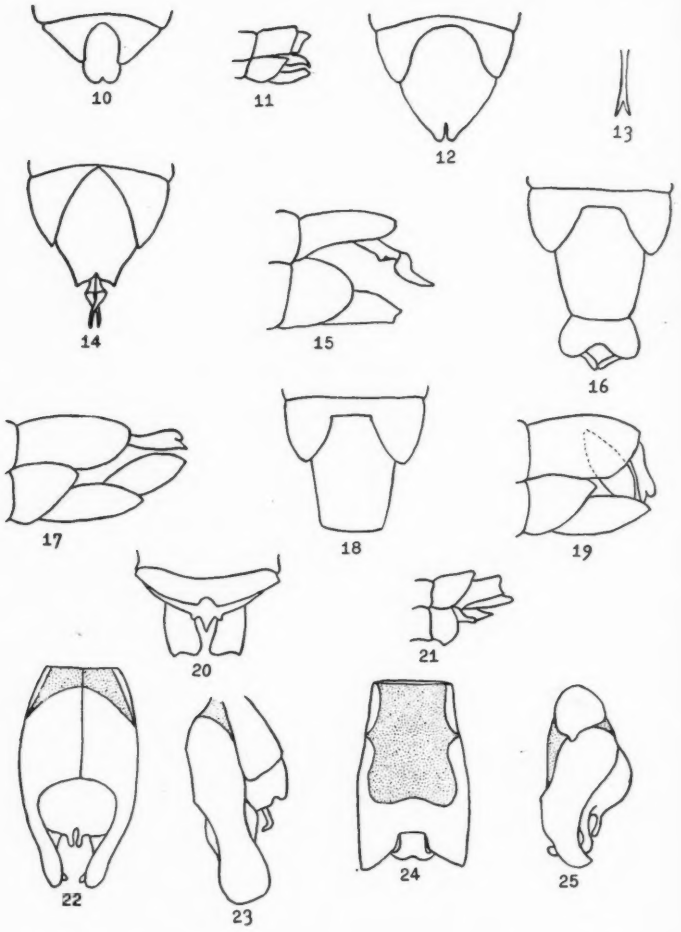

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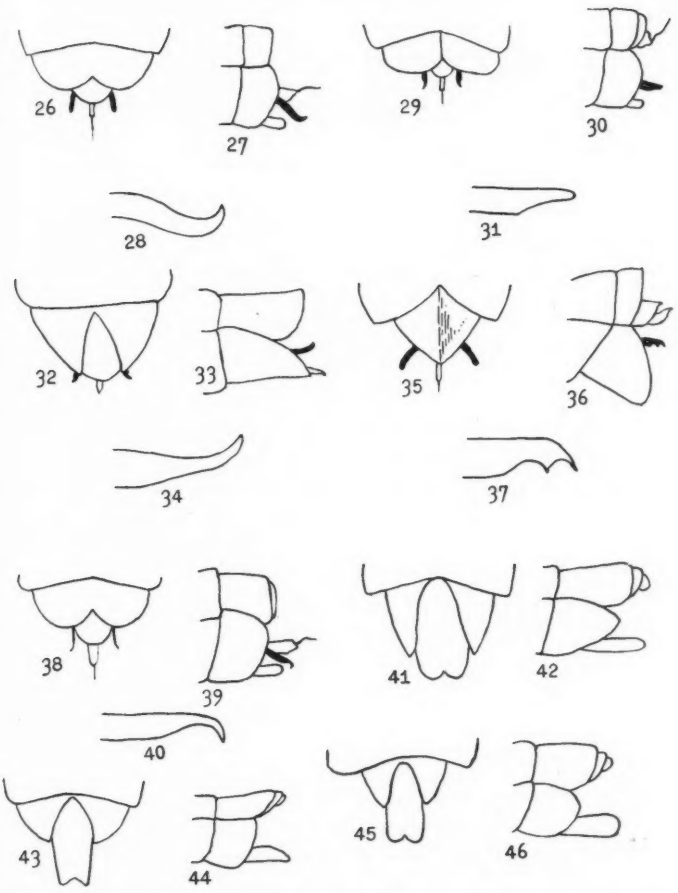

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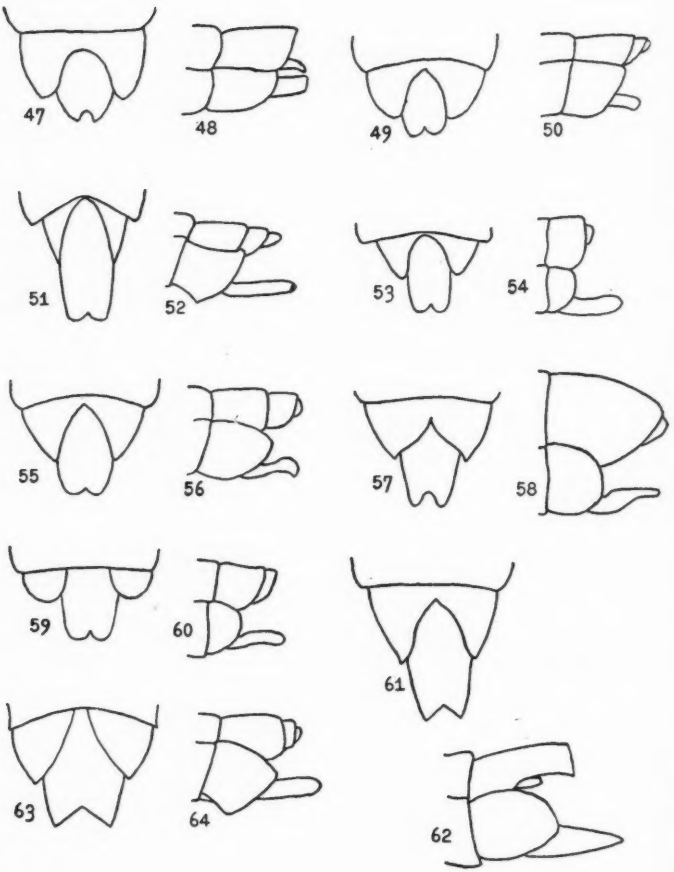

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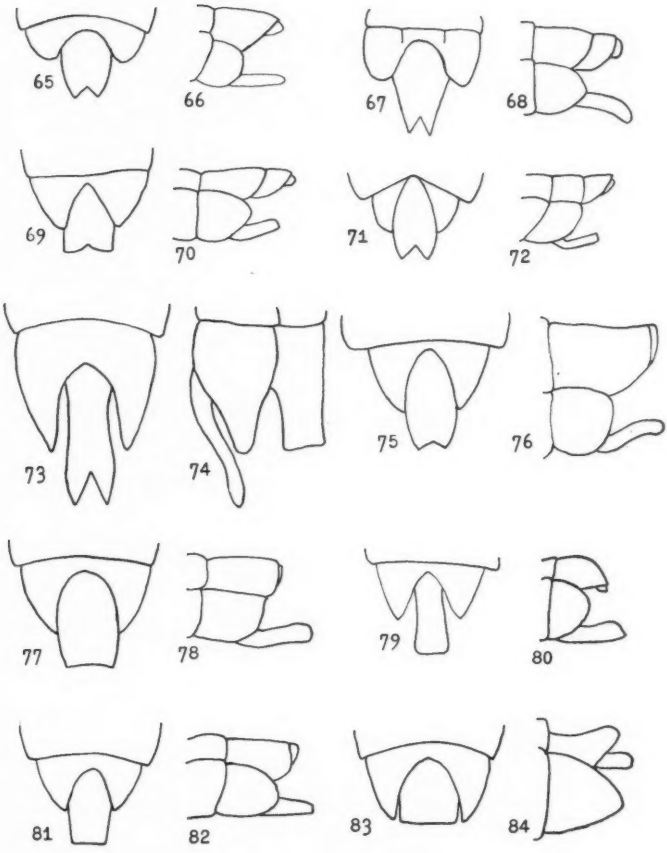

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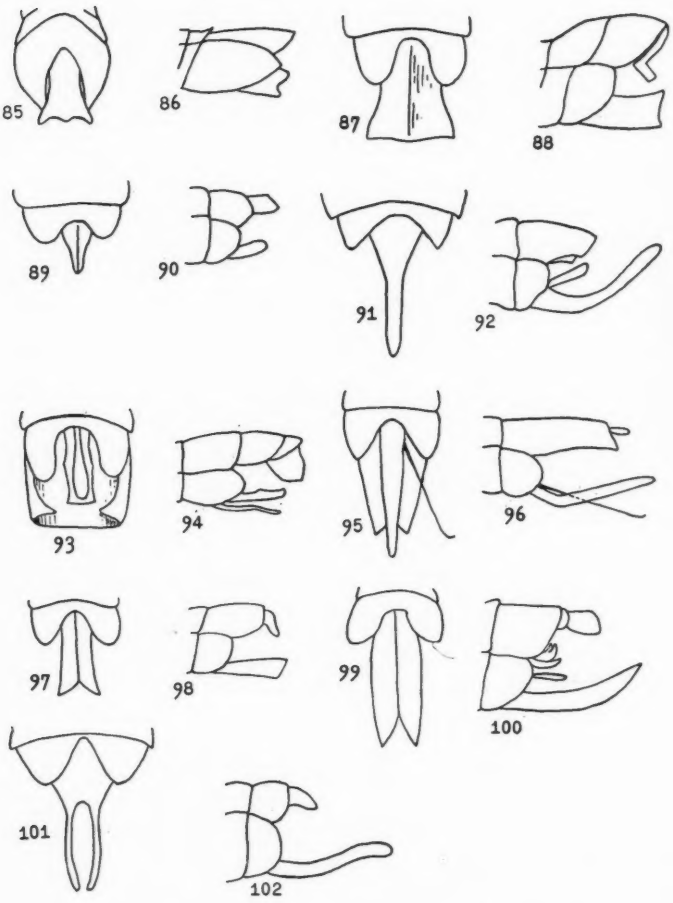

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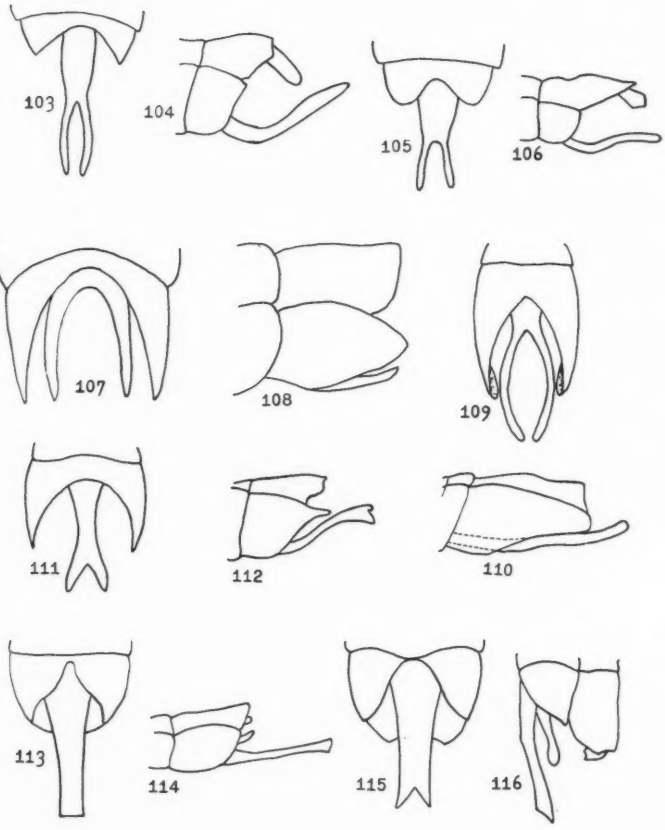

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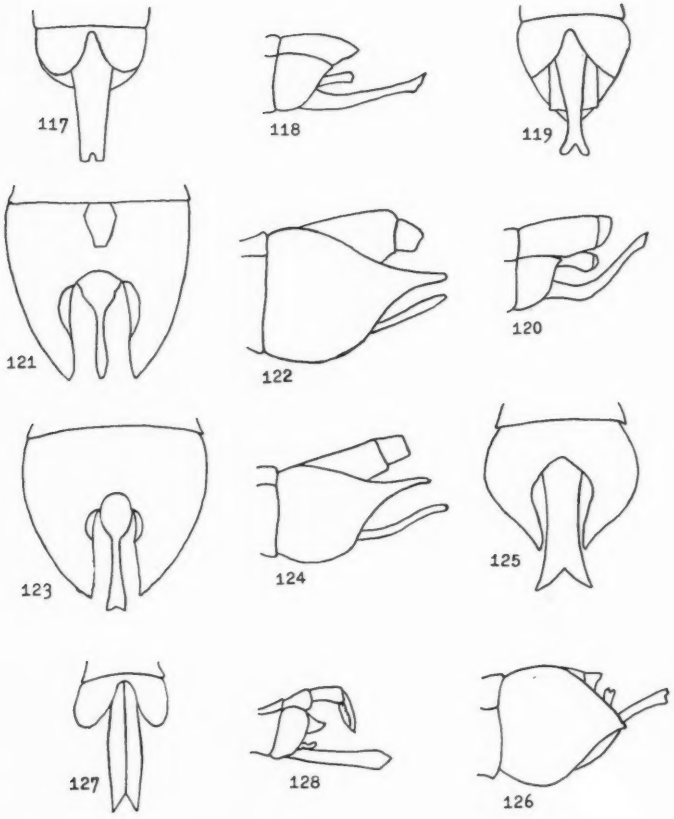

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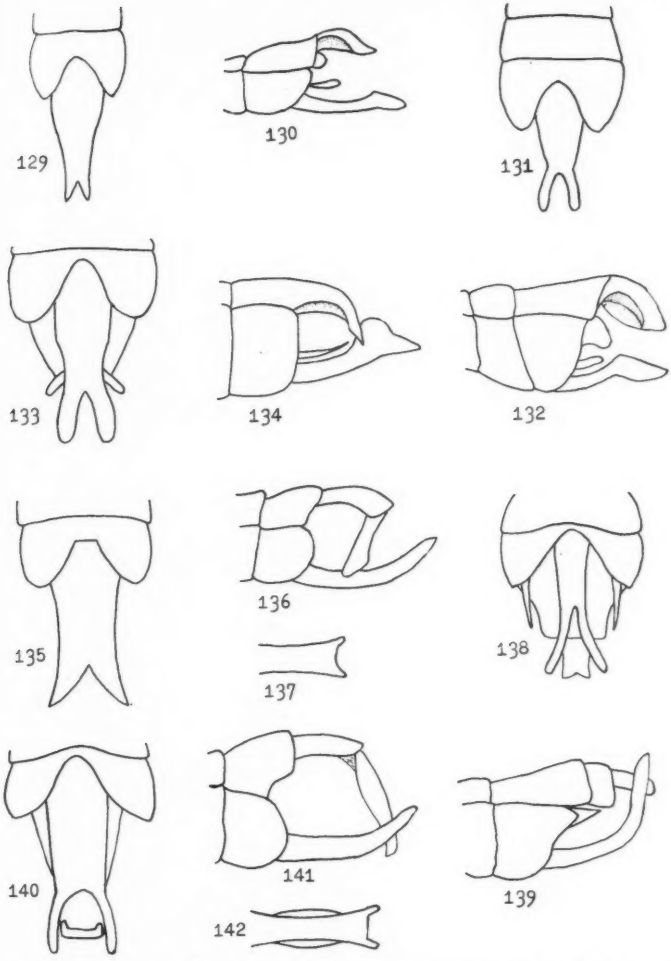

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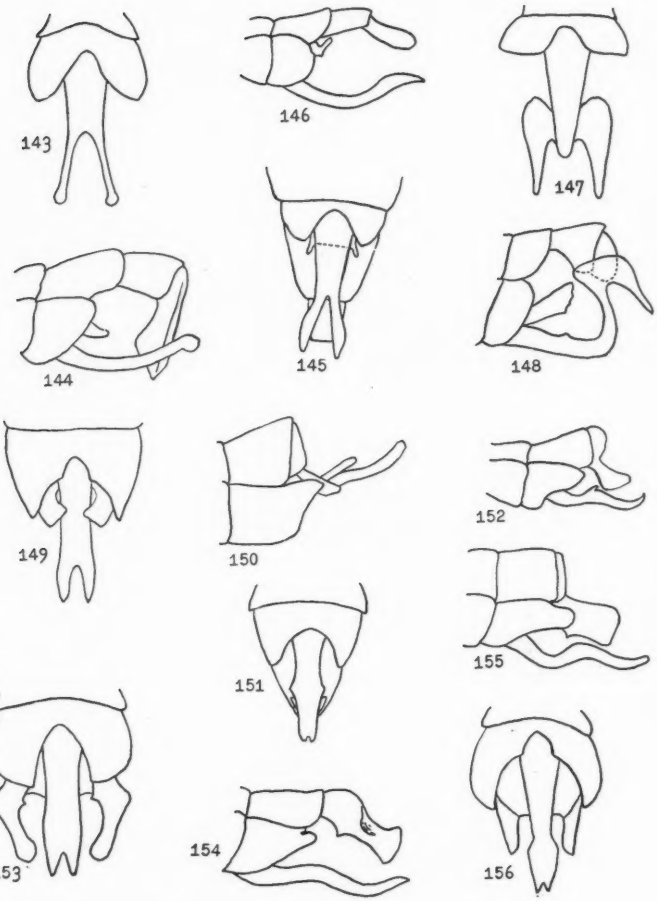

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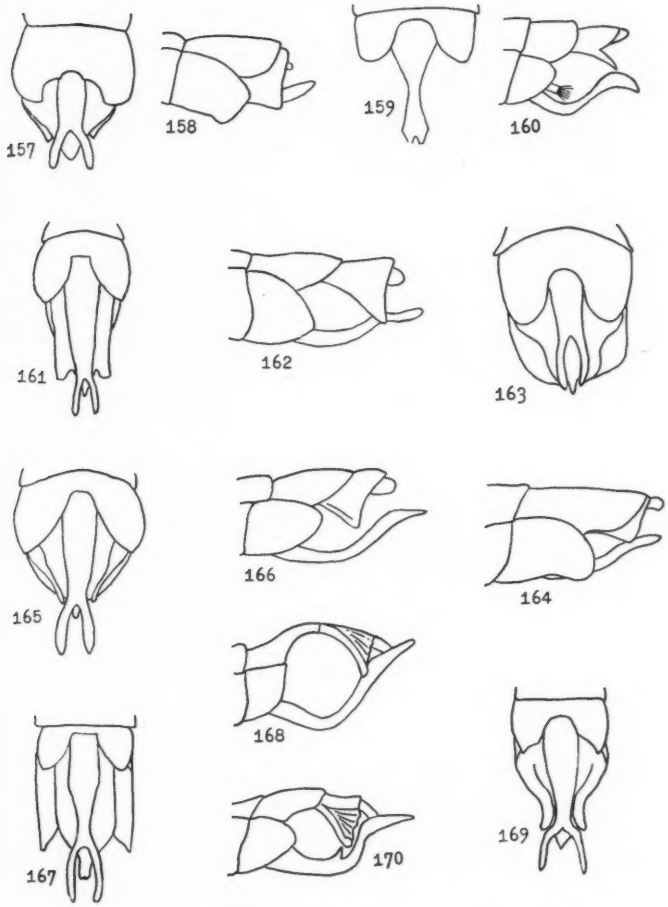

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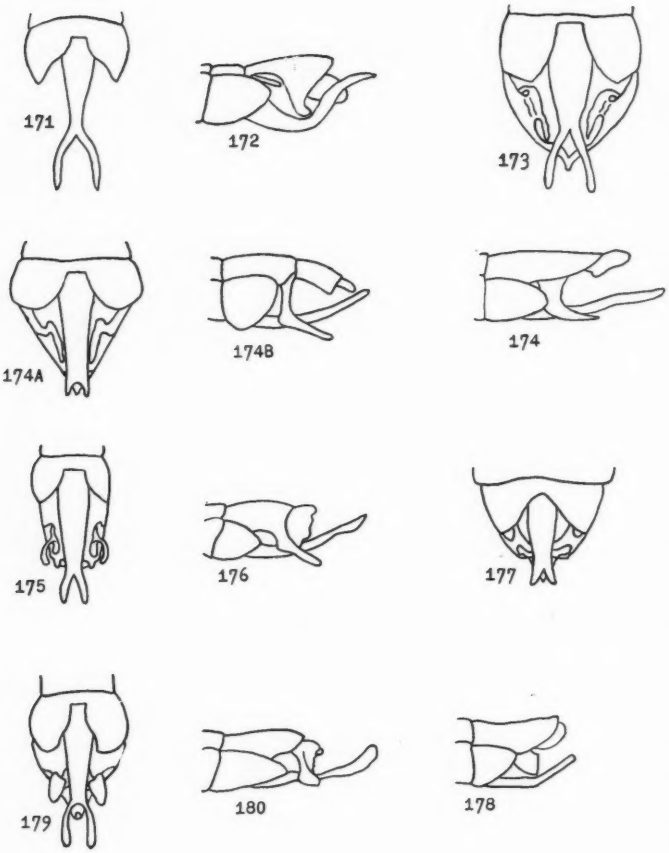

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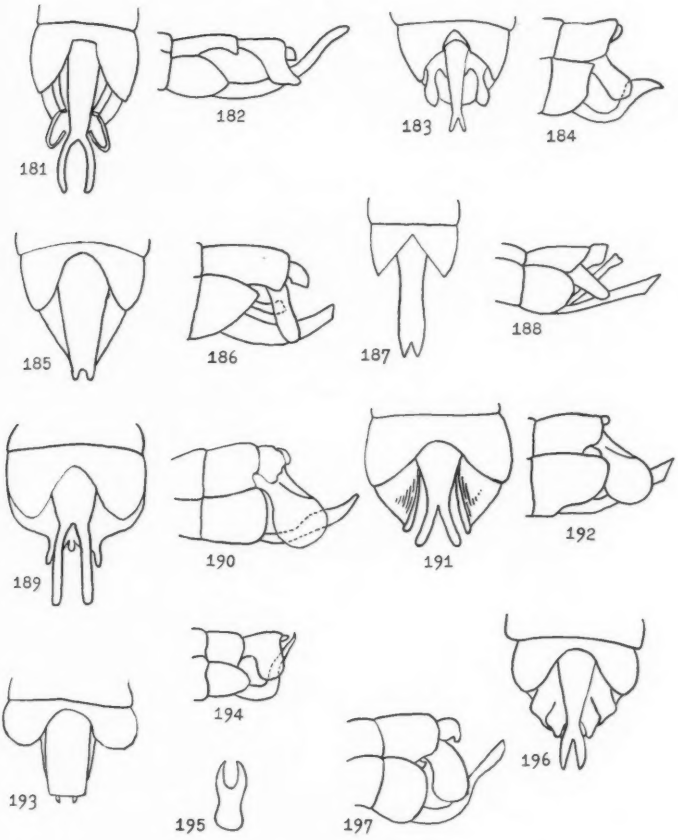

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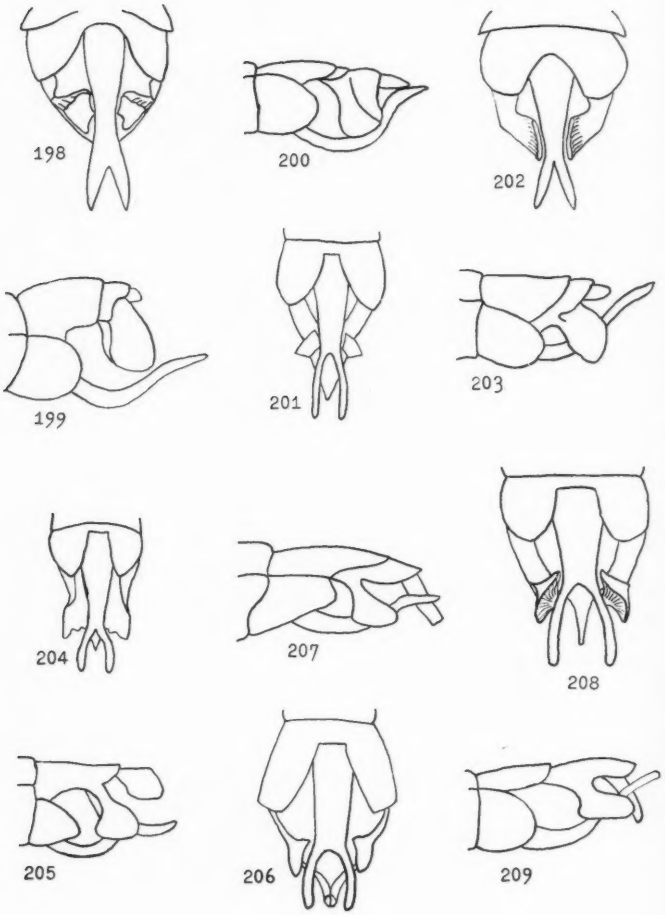

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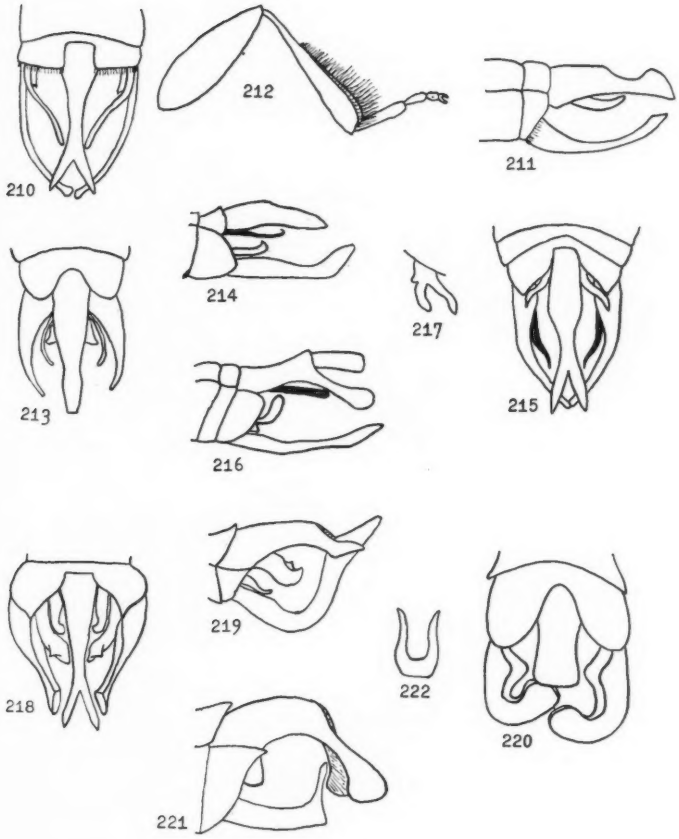

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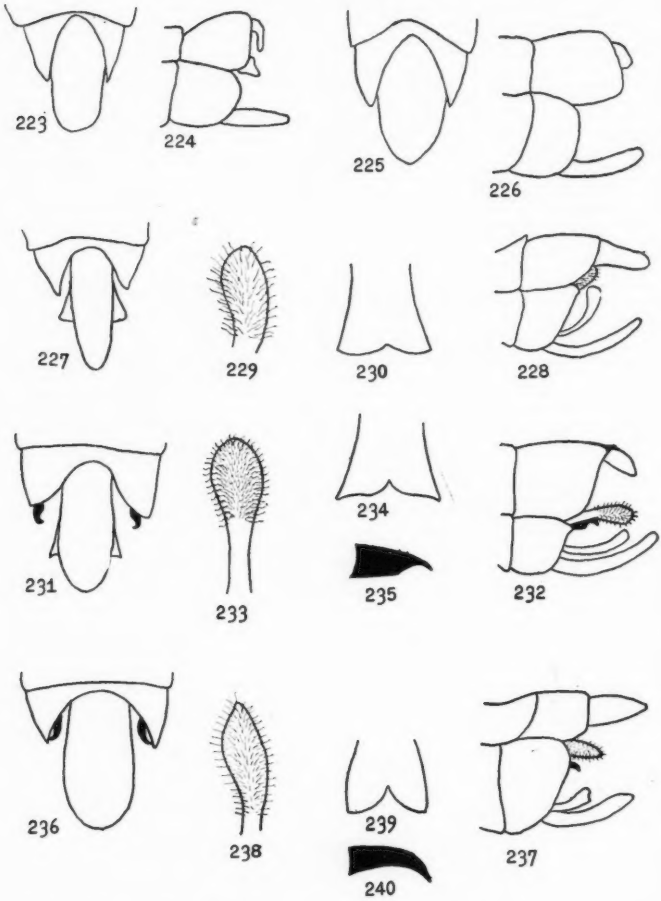

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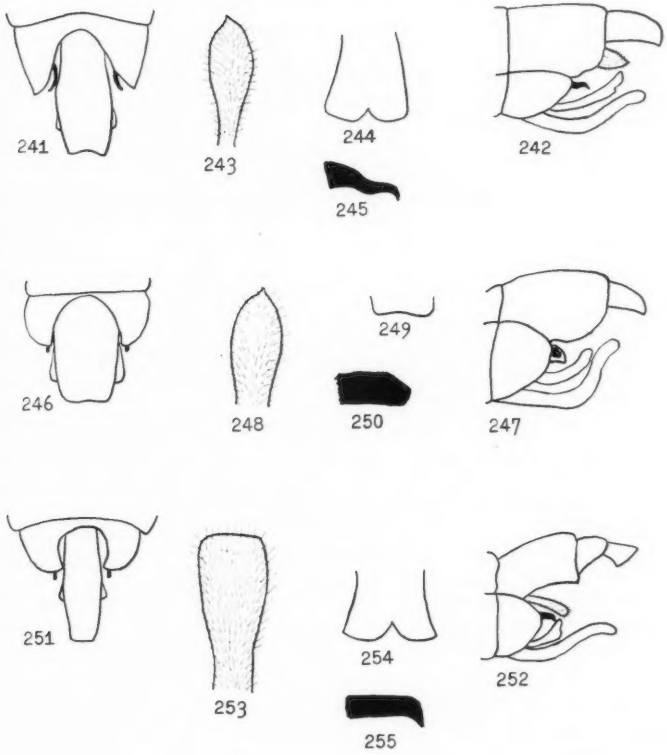

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A New Cantharis (Cantharidae, Coleoptera)

Dorothy McKey-Fender
McMinnville, Oregon

The following species and subspecies will usually be found in collections under the name *C. oregona* Lec. var. *B*, which it superficially resembles, though critical examination reveals it to be new. The author has at hand a large series, much of which was submitted by the University of Minnesota, through C. E. Mickel. H. E. Jacques, J. W. Green, F. S. Carr, M. W. Sanderson and Rev. Bernard Rotger have loaned fewer numbers, while from C. A. Frost a small number of specimens bearing H. C. Fall's labels have been received. The author's appreciation is expressed to these individuals.

Cantharis aneba new species

Brownish black, prothorax, scutellum, front of head, sides and apex of abdomen flavo-testaceous; ventral surface of first two antennal segments and elytral epipleura testaceous. Pubescence cinereous, short, fine, sparse and appressed.

Male: Length 8 mm., width at base of elytra 2 mm., antennae 5.5 mm. Head coarsely granulo-punctate especially on vertex, dull; clypeus and around eyes more finely punctate, often shining; area behind eyes often transversely rugose. Clypeus deeply nicked at center, oblique either side (Fig. 1), apices prominent, margin a little thickened and infuscate. Second antennal segment a little less than one-half length of third, fourth barely one-fourth longer than third, antennae long, two-thirds body length or slightly greater. Length of median antennal segments about four times their width, sub-terete, elongate sub-campanulate; first two segments polished, remainder dull. Eyes large, separated by a little more than two times their length as viewed from above.

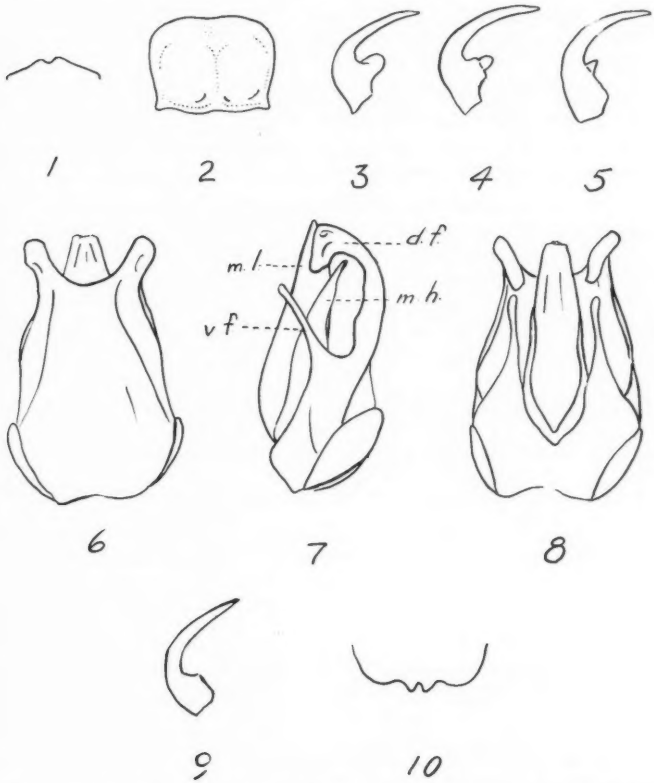
Pronotum subquadrate narrowing at posterior third, anterior angles not prominent, evenly, broadly rounded into the anterior margin which is very slightly convex and often shallowly incurved medially. Sides rarely a little sinuate behind anterior angles, making those a little more conspicuous. Posterior angles more prominent than anterior but usually obtuse. Posterior margin moderately convex from just within posterior angles, incurved at center; reflexed, most broadly so at center. Reflexed portion bounded anteriorly by an impressed line except for a narrow, anteriorly-extending sub-triangular area medially (Fig. 2); a distinct impressed line between the discal tumidities extending forward to anterior third. Surface shining; scattered irregular punctures over median portion of disc, fine and closer anteriorly, sometimes subscabrous. Disc narrowly shallowly concave within anterior angles. Sides thinned out, reflexed, especially anteriorly. Apex of scutellum blunt.

Elytra moderately stout, length equalling two and one-half times their

combined width; uniformly rugoso-tuberculate; longitudinal lines very faint, scarcely evident; suture not appreciably thickened.

Outer claw of protarsi with a broad, blunt tooth; mesotarsal tooth narrower, blunt; metatarsal tooth small, subacute (Figs. 3-5). Inner claw of all tarsi simple.

Genital armature testaceous, well chitinized. Dorsal forks of tegmen produced, involute, the apices divaricate, throat of divarication a U-shaped



Figs. 1-10. *Cantharis aneba* McKey-Fender.—1. Outline of anterior margin of clypeus. 2. Pronotum of male. 3. Outer protarsal claw of male. 4. Outer mesotarsal claw of male. 5. Outer metatarsal claw of male. 6. Male genital armature, dorsal view. 7. Same, lateral view—d.f., dorsal forks of tegmen; m.l., median lobe; v.f., ventral forks; m.h., median hook. 8. Same, ventral view. 9. Outer tarsal claw of female, any tarsus. 10. Outline posterior margin of seventh sternite of female.

space, the tips expanded apically, broadly down-curved; ventral forks of tegmen slender, produced, very gently arcuate with the tips directed ventrally; median hooks flattened, elongate-triangular or cultellate; median lobe strongly chitinized, equalling dorsal lobe in length (Figs. 6-8).

Female: Stouter than male, antennae shorter; length 8.5 mm., width at base of elytra 2.75 mm., antennae 5 mm.; antennal segments more nearly terete, less noticeably campanulate, median segments not more than four times as long as wide. Eyes small, separated by more than three times their length as viewed from above.

Pronotum transverse; median impressed line not deep, less conspicuous than in male.

Elytra stout, length less than two times combined width. Short, just long enough to cover abdomen in typical specimens.

Claws all simple, the base merely a little thickened (Fig. 9).

Last ventral produced, emarginate apically (Fig. 10).

Range: This species appears to be especially abundant in Minnesota, being second only in numbers to the common *C. carolina* Fab. among the larger Cantharis submitted to the author by the University of Minnesota. It appears to be less abundant southward (Illinois, Iowa, Nebraska and Colorado). Northward, where it is represented by a subspecies described below, its relative abundance could be greater than it appears, as few collections from Saskatchewan and Alberta have been seen. It is relatively rare in British Columbia.

Type: male—Minn., Otto Lugger col. (Cal. Acad. Sci.).

Allotype: female—same data(Cal. Acad. Sci.).

Paratypes: COLORADO—*Boulder;* May 25, 1938, M. T. James, 1 female: *Ft. Collins;* May 14, 1932, at light, 1 male, Rotger col.

ILLINOIS—*Algonquin;* Nason, 1 female, 1 male; *Cook Co.;* 1 female; *Lake Co.;* June 13, 1926, 2 females.

IOWA—*Sioux City;* June 13, 1922, C. N. Ainslee, 1 male; *County* 3, June 25, 1935, Gould Warren, 1 male; June 15, 1937, George Crane, 1 male.

SOUTH DAKOTA—*Volga;* Truman, 3 males, 2 females.

MINNESOTA—no further data, Otto Lugger col., 4 females, 1 male: *St. Paul;* May 25, 1932 (2), May 26, 1936 (2), May 29, 1935 (3), June 1, 1932 (1), June 9, 1935 (1), June 12, 1935 (2), all specimens males, taken at light trap; A. A. Granovsky coll.: May 19-23, 1922, 19 males, at light, Wm. E. Hoffman; May 24, 1926, Sam Epperley, 3 males: *St. Anthony Park;* May 16, 1911, 2 males, 1 female; no further data, Otto Lugger col. 1 male, 1 female; *Goodhue Co.;* May 29, 1939, Carl T. Schmidt, 1 male: *Otterl Co.;* Otto Lugger col., 2 males: *Hennepin Co.;* Otto Lugger col., 2 males: *Ramsay Co.;* Otto Lugger col., 1 male: *Winona Co.;* May 30, *Olmstead Co.;* 1 female, 1 male: *Wazzata;* June 1, 1923, J. A. Winter, 2 males: *Anoka Co., Fridley Sand Dunes:* June 3, 1933, C. E. Mickel, 1 female: *Stafford Insec.,* June 1909, 2 males.

NEBRASKA—*Hecla;* May 25, 1928, 2 males, 1 female.

LOCALITY UNKNOWN—Otto Lugger col., 1 female.

Variation: Melanic individuals throughout the range of the species may have the pale borders of the abdomen narrow, sometimes nearly obsolete; the elytral epipleura and basal antennal segments in such examples also being dark.

In occasional specimens the femora are paler than tibia and tarsi, rufotestaceous or rufescent. In some males a pair of fuscescent pronotal spots may be present.

Cantharis aneba borealis new subspecies

Specimens of *C. aneba* from the north (N. Minn., Sask., Alberta, B. C.) differ notably from the typical in smaller size (averaging 1.75 by 7 mm., antennae 5 mm.). A pair of fuscescent pronotal spots is present in 32% of the northern males (4% in the typical form); the median impressed line of the pronotum is rarely conspicuous and the ungual teeth of the males are less strongly developed. The protarsal tooth being small and blunt (Fig. 4), the mesotarsal small and subacute (Fig. 5) and the metatarsal lacking as in Fig. 9. In one specimen of this subspecies at hand both the meso-and metatarsal claws are simple, while in one the ungual teeth are well developed as in the typical form. The ungual "tooth" in these beetles is a thin lamella, rather delicate and could conceivably be lost during life or later. This may have happened in the case of a specimen (cf *C. a. borealis*) exhibiting asymmetrical ungual armature, though it could scarcely account for the consistently weaker ungual armature in this subspecies.

Females of this subspecies tend to have the elytra abbreviated, covering little more than one-half to two-thirds of the abdomen, rarely covering the entire abdomen as in the typical form.

Type—male, *Saskatoon, Sask.;* June 1, 1906 (Cal. Acad. Sci.).

Allotype—female, *Rosetown, Sask.;* June 6, 1912 (Cal. Acad. Sci.).

Paratypes—ALBERTA—*Camrose;* July 1, 1920, C. E. Hendrickson, 1 female: *Edmonton;* June 3, 1915, June 3, 1919, F. S. Carr, 1 male, 3 females; May 23, 1916, 1 male.

BRITISH COLUMBIA—*Victoria;* 1 male: no further data, 1 male; B.C. or Sask., 1 male; V.I., 3 males.

MINNESOTA—*Norman Co.;* May 27, 1933, A. A. Nickol, 2 females, 1 male.

SASKATCHEWAN—*Saskatoon;* June 1, 1906, 2 males; *Redvers;* Chewan, June 7, 1908, 2 males: *Rosetown;* June 6, 1912, 1 male: *Regina;* June 1912, male and female on one pin; June 18, 1904, 1 male; Sask., no further locality, June 7, 1929, 1 male: *Friesland;* 1899, Otto Lugger col.

NO DATA—1 female (presumably from the Otto Lugger col.).

Affinities: Cantharis aneba is very closely related to *C. oregana* Lec. It differs, from the superficial standpoint, in being much less hirsute, the pubescence being cinereous rather than black; elytra brownish black rather than intense black; pale scutellum and elytral epipleura, the pronotum never with a black macula. The male genitalia, though clearly related, are sufficiently distinct from all members of the group to afford positive identification. Unfortunately *C. oregana* and the similar *C. scopa* Lec. are complex, widespread species including a number of subspecies or geographic races the status of which is yet being worked out; care, therefore, should be used in identifying even *C. aneba,* while few others of the group may be identified with any certainty.

The Circulatory System of the Box Elder Bug Leptocoris trivittatus (Say)

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Department of Zoology, Colorado A & M College, Fort Collins

Relatively little is known concerning the histology and morphology of the dorsal vessel of most insects. The vessel is well described for some species, but general knowledge of its structure in various insect groups is meager.

The dorsal vessel is delicate, requiring careful dissection and preservation. In addition, various parts, such as the ostia and the accessory pulsatile organs and membranes, when present, are difficult to observe. Some of these difficulties have been overcome in this work and the results are here presented.

Live insects were used in this study and the employment of vital stains aided immeasurably in observing and identifying the internal structures (Woolley, 1949).

Dissections were made in saline solution. The entire organ or its parts were fixed in Kahle's or Carnoy's solutions, washed in alcohol and imbedded and preserved in paraffin. In addition to the gross dissections, whole mounts and serial sections were employed for details. Sections of the tissue were cut at 5, 7, and 10 microns, mounted and stained with one of the following: Hansen's Trioxyhaematin; Heidenhain's Iron Haematoxylin; Eosin and Fast Green; Eosin and Delafield's Haematoxylin.

A camera lucida was used for the histological drawings. Details were added after a careful sketch had been made of the structure to be illustrated. The drawings of the gross anatomy were made free hand.

The Dorsal Vessel

The heart.—Grobben (1875) shows a two-chambered heart with a single pair of ostia for *Aleurodes*. Witlaczil (1884) figures the heart of *Drepanosiphum* as having eight chambers and seven pairs of ostia. Murray (1914) describes two chambers in the heart of *Cimex lectularius* and mentions that the ostia occur on the sides of these pouches, but he gives no definite number of valves for the insect. Hamilton (1931) says that the heart of *Nepa* is five-chambered and perforated by four pairs of ostia. Malouf (1933) found four chambers and three pairs of ostia in the heart of *Nezara viridula*. Essig (1942) states that the Hemiptera in general have five-chambered hearts.

The heart of *Leptocoris* is a large, bulbous chamber perforated by two pairs of ostia (fig. 1). The single chamber is elongated anteriorly into a

* Part of dissertation presented for degree of Doctor of Philosophy, Department of Zoology and Entomology, The Ohio State University, Columbus.

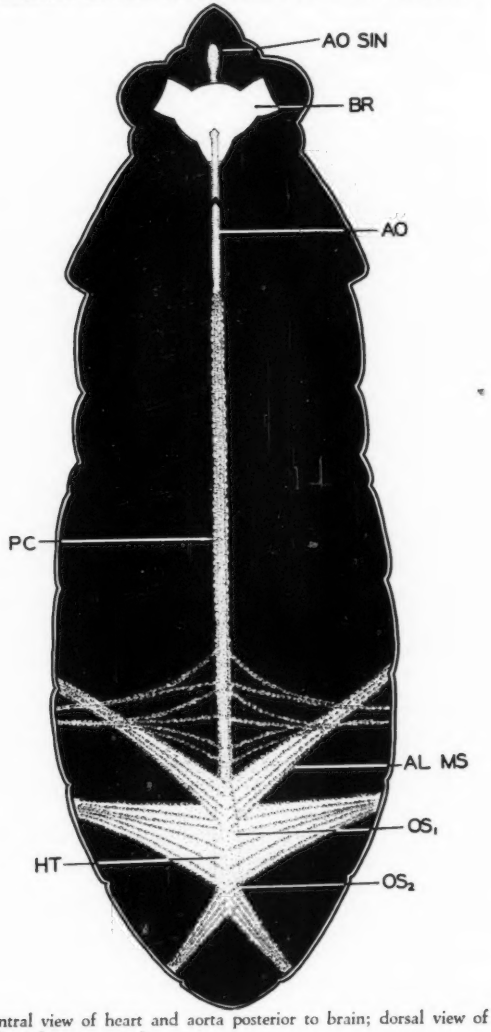

Fig. 1.—Ventral view of heart and aorta posterior to brain; dorsal view of brain and aortal sinus. (Semi-diagrammatic.)

Abbreviations: AL MS—Alary Muscle of the Heart; AO—Aorta; AO SIN—Aortal Sinus; BR—Brain; F B—Fat Body; HT—Heart; HT CAV—Heart Cavity; HT W—Heart Wall; N—Nucleus; OS_1—First Ostium; Heart $Valve_1$; OS_2—Second Ostium; Heart $Valve_2$.

slender aorta. Posteriorly, the heart is attached to the anal body wall by caudo-lateral muscle strands (fig. 1). The bulbous chamber is also suspended from the dorsal body wall by fine muscular threads (fig. 5). Lateral muscle strands also act as attachments for the bulbous portion.

The aorta is unattached except at the anterior end where the open vessel fans out. The dorso-ventral expansion of the aorta at this point forms a sinus similar to that described for *Rhodnius* by Wigglesworth (1947). A point of support or attachment might also be considered to be the area in which the aorta is closely invested by the brain, through which the vessel extends. The sinus is anterior to the brain and the vessel fans out dorsally. The aorta is attached to the dorsal head wall for about sixty microns of its length at this point. This expanded portion lies above the dilator muscles of the pharyngeal pump (Woolley, 1949).

The aorta becomes narrowed posterior to this sinus and extends caudad through the brain. The vessel lies dorsal to the oesophagus. Immediately behind the brain the aorta widens briefly in the area of the caudo-lateral muscles of the bulbous pharynx anterior to the oesophagus. Here the aorta appears to be pinched dorso-ventrally also between the fat body and the corpus allatum. The aorta becomes wider caudad of this point and is somewhat flattened. The collapsed or pinched tube lies dorsal to the ventriculus or stomach proper (Woolley, 1949).

The heart and the aorta are invested by mononucleate pericardial cells (nephrocytes), which give the gross surfaces of both structures a beaded appearance (fig. 1). The external vesture of the aorta surrounds the vessel for approximately two-thirds of its length. The vesture ends in the thoracic region near the anterior end of the dorso-ventral thoracic muscle mass. For the remainder of the extension of the aorta into the head, these vesture cells are few. Isolated pericardial cells were found unattached in the body cavity and some were found adjacent to the aorta anterior to the thorax.

The alary muscles and pericardial septum.—Brocher (1917) notes that "some diaphragms have very little true muscle tissue and the fibers are not attached to the heart." Hamilton (1931) observes that there are muscle fibers with large, distinct cross striations in them. The writer found that *Leptocoris* has alary muscles similar to the latter description. These muscles attach directly to the heart and extend laterally to form the pericardial septum (figs. 5, 6).

The dorsal diaphragm or pericardial septum is confined to a few pairs of wedge-shaped alary muscles of the heart and several isolated strands anterior to the latter (fig. 1).

The six isolated strands of muscles anterior to the first wedge-shaped alary muscles of the heart extend directly laterad from origins similar to those of the main pairs of alary muscles. The strands are attached to the heart wall and the terga of the fourth abdominal segment. All of the strands are clothed with pericardial cells (fig. 1), which present the same beaded appearance mentioned previously for the heart and the aorta.

There are three main pairs of muscles suspending the heart from attach-

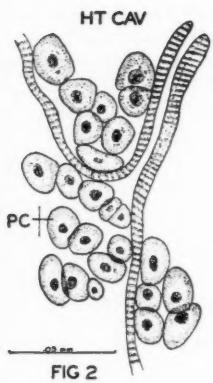

FIG 2

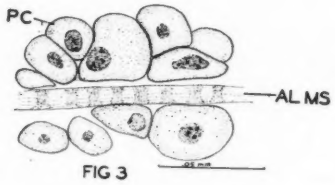

FIG 3

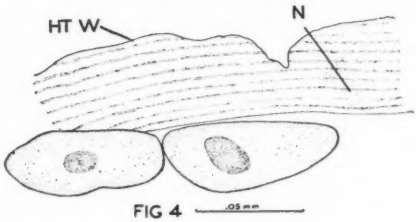

FIG 4

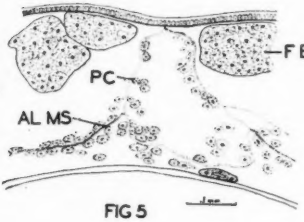

FIG 5

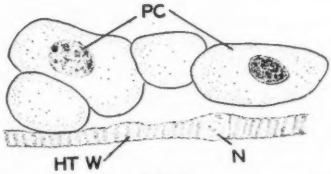

FIG 6

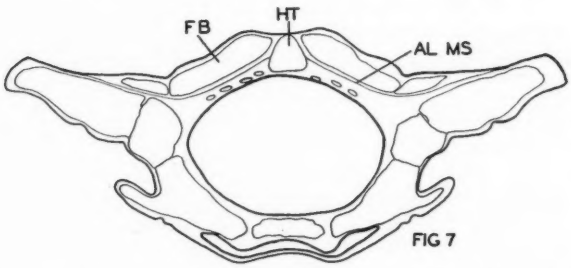

FIG 7

Figs. 2-7.—2. Longitudinal section through an ostium, showing pericardial cells and striated heart wall; 3. Section of alary muscle, showing striations and pericardial cells; 4. Tangential section of heart wall, showing longitudinal striations; 5. Cross section of heart showing dorsal attachments, pericardial cells and alary muscles. (Semi-diagrammatic); 6. Longitudinal section of heart wall; 7. Cross section of abdomen, showing heart and attachments of alary muscles. (Diagrammatic.) See fig. 1 for abbreviations.

ments at the lateral edges of the third-, fourth-, fifth-, and sixth-abdominal terga. The two anterior pairs of heart wing-muscles project antero-laterad and attach to the edges of the terga in the third and fourth and fifth abdominal segments The anal pair of alary muscles of the heart project caudo-laterad and attach in the seventh abdominal segment.

Wigglesworth (1947) recognizes a ventral diaphragm in Orthoptera, Odonata, Ephemeroptera, Hymenoptera and Lepidoptera. He states that the diaphragm is a "fibro-muscular septum stretched across the abdomen just above the nerve cord, thus enclosing below it a perineural sinus. This membrane is capable of undulating movements, which direct the flow of blood beneath it backwards and laterally and ensure the irrigation of the nerve cord." Snodgrass (1935) mentions that there is no ventral diaphragm in insects which have the ventral transverse muscles compacted into bundles. In insects which have a ventral diaphragm these muscles are continuous transversely and are held within a membrane to form a ventral diaphragm above the nerve cord. There is no ventral diaphragm in *Leptocoris*.

The pericardial cells.—According to Puri (1924) the pericardial cells or nephrocytes of *Cimex* are grouped into clusters in various regions along the dorsal vessel and the dorsal diaphragm. The nephrocytes of *Leptocoris* closely invest the heart and the aorta. The pericardial cells also clothe the alary muscles of the heart (fig. 1). This vesture is complete and not in clusters. The layer or coating may become two or three cells thick in some areas (fig. 3).

Pantel (1913) describes a preventricular cushion of cells in the intermediate trunk of the dorsal vessel of *Ceromasia*. The cushion is formed of cells unlike those of the heart wall. The condition found by Pantel suggested the possibility that inasmuch as cells do occur in the lumen of the dorsal vessel of *Leptocoris* a similar cushion might be found. The box elder bug does exhibit many cells within the heart cavity (fig. 2), although the author did not find any such cushion-like arrangement of cells in the heart or aorta. It is extremely noticeable, however, that the cells of the lumen of both the heart and aorta are exactly like the nephrocytes investing the outsides of these structures. The cells within the cavities of the dorsal vessel are mononucleate; they fix and stain like the pericardial cells. The writer has assumed them to be the same type of cells as those which invest the outside of the heart and aorta and alary muscles of the heart. In appearance there is no difference. It is not illogical to suppose, furthermore, that these cells may migrate in the blood of the insect, enter the heart cavity and become attached to the inner surface of the dorsal vessel.

Histology.—Wigglesworth (1947) cites three types of strructures for the heart wall. First, the heart wall is made up of a single layer of cells, their substances differentiated into circular fibrillae, indistinctly striated, enclosed between two homogeneous membranes. The latter condition is typical of Diptera and was described for *Thrixion* by Pantel (1898). Secondly, the muscles may consist of interlacing, striated fibrillae embedded in sarcoplasm, as in *Aeschna*, and described by Zawarzin (1910). Thirdly, the heart wall

may be composed of longitudinal and circular fibrillae as described for *Nepa* by Hamilton (1931).

Wigglesworth (1947) also states that the heart and aorta frequently have the same histological structure and both are contractile; usually the outer membrane is covered with an adventitia of connective tissue carrying the tracheoles. (This adventitia corresponds to the "pericardium" of Murray and Tiegs, 1935).

Hamilton (1931) describes the heart wall of *Nepa* as consisting of a single layer of cells, the cytoplasm of which is differentiated into circular and longitudinal fibrillae.

The heart wall of *Leptocoris* is typical of the third type described by Wigglesworth and very similar to that described in *Nepa* by Hamilton. The heart wall of the box elder bug is composed of longitudinal and circular fibrillae embedded in sarcoplasm. The wall is one-cell thick and the nuclei are centrally located, although some of the latter appear to be peripheral in location (fig. 6). The cells of the wall in cross section seem disc-like and appear to be pierced by longitudinal fibers. Both the heart and the aorta have the same histological structure.

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A Comparative Study of the Food Habits of Cottus bairdii and Associated Species of Salmonidae[1]

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Large populations of *Cottus bairdii bairdii* Girard, the common sculpin, are numerous in many of the small streams throughout Minnesota. *Salmo trutta fario* Linnaeus, the brown trout, and *Salvelinus fontinalis fontinalis* (Mitchell), the common brook trout, are popular game fish in these same streams. The major objective of this study was to determine the extent to which the sculpins and trout were competitors for food. Since the fishes were taken during the fall spawning season of the trout, it was possible to gather some evidence on the question of sculpins eating the eggs of trout.

Habitats.—The fishes were taken from one area of the Caribou River in northeastern Minnesota and from two different areas of the Root River in southeastern Minnesota. The Caribou River is part of the Great Lakes drainage system. The Root River drains into the Mississippi River. Overhanging banks covered with tag alder afforded excellent shelter for the trout and sculpins in the collecting area of the Caribou River. The river was about 12 feet wide and varied in depth from 2 to 3.5 feet. The water flowed fairly rapidly over a stony bottom, with many large boulders. Collecting area A of the Root River was located in a creek midway between its source and its junction with a main branch of the river. The banks of the creek indicated heavy soil erosion. There were many shelter pools, but the rooted aquatic vegetation was very limited. The second collecting area (B) of the Root River was in a creek approximately three-eighths of a mile from the source. It flowed through a wooded lowland. Overhanging banks and shelter pools were very limited, but rooted aquatic vegetation was common. The water was clear, cold, and 12 inches deep.

Methods.—The electric shocking method was employed in collecting the fishes. Each trout stomach was removed and preserved in an individual jar. The species and standard length were recorded on the label. All of the sculpins were preserved in formalin. The numbers and standard lengths of the trout and sculpins utilized in this study are recorded in Tables I and II, respectively. In the laboratory the contents of the stomachs were examined under a binocular microscope. The number and frequency of occurrence of each food item are summarized in Tables IV-VI. The availability of food

1 The data in this paper were taken from a thesis presented to the graduate faculty of the University of Minnesota, in partial fulfillment of the requirements for the degree of Master of Science. The writer wishes to express his gratitude to Dr. Samuel Eddy, Professor of Zoology, University of Minnesota, for his direction and to the members of the Minnesota Conservation Department, Division of Fisheries Research for making the materials available.

was determined by examining the bottom fauna from quadrats laid out in the collecting areas. Unfortunately, no samples were taken in area B of the Root River. The frequency of occurrence of bottom organisms in each of the other areas is recorded in Table III.

TABLE I.—Numbers of trout and sculpins used in this study

	Caribou River	Root River Area A	Root River Area B	Totals
Brook trout	27	—	9	36
Brown trout	19	213	24	256
Sculpins	213	170	691	1074

TABLE II.—Standard lengths of trout and sculpins used in this study

	Range (mm.)	Mean (mm.)
Brook trout	125-225	144
Brown trout	125-325	181
Sculpins	25-110	60

TABLE III.—Frequency of occurrence of bottom fauna
Percentage of individuals

	4 Quadrats** Caribou River	12 Quadrats Root River Area A
Snails	0.2	—
Amphipods	—	10.9
Crayfishes	—	*
Leeches	0.5	—
Oligochaetes	11.3	3.0
Spiders	—	*
Mites	—	*
Insects		
Orthoptera	—	*
Plecoptera	10.5	*
Ephemerida	40.6	15.5
Hemiptera	—	*
Trichoptera	30.0	56.2
Coleoptera	0.3	0.1
Hymenoptera	—	*
Diptera	6.6	14.2

* Less than 0.1%.
** Each 18 inches square.

Bottom fauna.—Mayflies, caddisflies, and aquatic dipterans (largely chironomids) were common in the bottom fauna collections from both the rivers (Table III). Also, oligochaetes and stoneflies were numerous in the Caribou River and amphipods (*Gammarus*) were plentiful in collecting area A of the Root River. With the exception of oligochaetes, the common bottom organisms were consumed by the trout and sculpins in proportion to their availability. All of the leading food items of the sculpins and five of the six major food items of the trout were bottom dwellers.

Food.—The amount of vegetable matter found in the stomachs of the sculpins and the trout was negligible. A few trout stomachs contained seeds and fragments of plants. Filamentous algae were frequently entangled with the immature insects, but no stomach contained a large quantity of plant material.

Salmonid eggs were eaten by the trout and the sculpins in collecting area A of the Root River. The sculpins were apparently much less destructive than the trout. The stomachs of 4.0 per cent of the sculpins and 15.4 per cent of the trout contained eggs. The stomach of one 300 mm. trout contained 161 eggs. The greatest number of eggs in any one sculpin stomach was three.

The frequency of occurrence of fishes in the stomachs of the trout from the different collecting areas ranged from 6.6 to 37.5 per cent. These forage fishes were largely small sculpins. No fish remains were found in the stomachs of the sculpins.

Gammarus constituted a major food item of both the brown trout and the sculpins from area A of the Root River (Table VI). The amphipods were apparently not available in the other collecting areas. The bottom fauna collections from the Caribou River did not contain amphipods. Crayfish remains were found in the stomachs of a few trout.

Snails, all *Physa* with the exception of one *Planorbula*, were eaten in small numbers by the trout and sculpins. One stomach of a sculpin contained 5 large *Physa*.

Centipedes, leeches (*Erpobdella* and *Glossiphonia*), spiders and aquatic mites were minor food items of the trout. The frequency of occurrence of spiders (44% in area B) as well as terrestrial insects in the diet of the trout indicated a considerable amount of feeding at the surface of the water. Oligochaetes and aquatic mites were minor food items in the diet of the sculpins.

As indicated by the number and frequency of occurrence (Tables IV-VI), the immature stages of four orders of insects; namely, Plecoptera, Ephemerida, Trichoptera, and Diptera were very important food items of both the trout and the sculpins. Aquatic hemipterans and coleopterans were minor food items. Since the trout fed to a certain extent at the surface of the water, several orders of terrestrial insects constituted a part of their diet (Tables IV-VI). However, inasmuch as the fishes were collected in the fall, the importance of surface feeding to the trout was probably greatly reduced.

TABLE IV.—Analyses of the food contained in the stomachs of 27 brook trout, 19 brown trout and 213 sculpins from the Caribou River.

Food Item	Brook Trout		Brown Trout		Sculpin	
	Composition by count of ind. (%)	Freq. of occur. (%)	Composition by count of ind. (%)	Freq. of occur. (%)	Composition by count of ind. (%)	Freq. of occur. (%)
Fishes	0.3	7.4				
Snails	0.1	3.7	0.4	5.3	0.4	0.9
Leeches	0.2	3.7	0.4	5.3		
Oligochaetes					1.6	2 4
Spiders	0.3	3.7				
Mites	0.4	3.7				
Insects:						
Plecoptera	3.6	40.7	3.4	26.3	4.9	6.6
Ephemerida	16.3	66.6	33.8	79.5	43.1	44.6
Hemiptera	0.5	14.8				
Homoptera	0.1	3.7				
Trichoptera	69.7	96.2	57.4	90.1	42.2	48.8
Lepidoptera	0.5	14.8	0.4	5.3		
Coleoptera	0.9	18.5	2.7	26.3	0.6	0.9
Hymenoptera	0.4	11.1	0.4	5.3		
Diptera	6.7	48.1	1.1	15.8	7.2	11.6

TABLE V.—Analyses of the food contained in the stomachs of 9 brook trout, 24 brown trout, and 691 sculpins from area B in the Root River

Food Item	Brook Trout		Brown Trout		Sculpins	
	Composition by count of ind. (%)	Freq. of occur. (%)	Composition by count of ind. (%)	Freq. of occur. (%)	Composition by count of ind. (%)	Freq. of occur. (%)
Fishes	0.7	11.1	6.6	37.5		
Snails					0.4	0.9
Crayfishes	0.7	11.1				
Oligochaetes					0.7	1.9
Spiders	3.5	44.4	2.2	4.2		
Mites			1.5	8.2	0.1	0.2
Insects:						
Orthoptera	2.8	33.3				
Plecoptera					0.1	0.2
Ephemerida	21.4	77.8	15.0	19.8	6.6	14.2
Hemiptera	7.6	44.4	2.2	12.5	0.1	0.3
Trichoptera	25.8	100.0	47.8	66.7	26.1	33.5
Lepidoptera					0.2	0.5
Coleoptera	6.3	66.6	6.7	25.0	1.9	3.5
Hymenoptera	1.4	22.2				
Diptera	29.8	100.0	18.0	25.0	63.8	52.4

TABLE VI.—Analyses of the food contained in the stomachs of 213 brown trout and 170 sculpins from area A in the Root River

Food Item	Brown Trout		Sculpins	
	Composition by count of ind. (%)	Freq. of occur. (%)	Composition by count of ind. (%)	Freq. of occur. (%)
Fishes	0.6	6.6		
Salmonid eggs	22.5	15.4	3.1	4.0
Snails	0.1	7.9	0.4	0.5
Centipedes	0.1	0.6		
Amphipods	18.0	26.7	18.2	26.4
Crayfishes	0.1	0.6		
Spiders	0.4	3.7		
Insects:				
Orthoptera	0.6	7.0		
Plecoptera	0.1	1.4	0.8	1.6
Ephemerida	2.8	9.6	11.7	14.0
Hemiptera	6.6	32.3		
Homoptera	0.5	1.9		
Trichoptera	40.6	58.6	41.6	58.0
Lepidoptera	0.1	0.6		
Coleoptera	3.5	20.5	0.7	1.6
Hymenoptera	0.8	0.6		
Diptera	2.6	15.0	23.5	23.3

Conclusions.—The five major food items of *Cottus bairdii;* namely, *Gammarus* and the immature stages of mayflies, caddisflies, stoneflies, and aquatic dipterans are also major food items of the brook and brown trout. Competition is lessened by the fact that the trout feed at all levels in the water whereas the sculpins are restricted to the bottom fauna. Competition would be increased during the winter months when the feeding habits of trout would be limited to the bottom fauna and to forage fish. Forage fishes constitute an additional major food item of the trout. In this study the forage fishes were largely small sculpins.

Sculpins eat a limited number of trout eggs, but in this study eggs did not constitute an important food item of the sculpins. Evidence indicates that the trout are more destructive to their own eggs than are the sculpins.

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Cryptorchid Fur Seals

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In an investigation of the Alaska fur seal (*Callorhinus ursinus*) on the Pribilof Islands, we have examined five cryptorchids, or males with infantile testes. Among wild animals in general, with the exception of the Cervidae, cryptorchids are difficult to recognize and to collect for scientific study. For this reason, a brief description of cryptorchidism as exhibited in the fur seal may be of general interest. On the Pribilof Islands, the local name for a cryptorchid is "big cow." Government employees who manage the fur seal industry report that one or two of these animals are observed each summer, representing an incidence of one in 5,000 or 10,000 adult males.

Behavior.—The cryptorchid gives the impression of being a stupid animal; slow in reacting to danger and shambling in gait. During the height of the mating season in mid-July, a normal adult bull on the fringe of Reef rookery was in control of only one animal, a cryptorchid which we later collected as specimen No. 86. This creature displayed neither the truculence of a bull nor the nervousness of a cow. It could be approached within two or three paces. Its quiet behavior and lack of musky, male odor doubtless enabled it to pass as a female. To do so was perhaps not difficult, as the bull seal is notoriously indiscriminate in selecting a mate. Attempted copulation with young males and with dead females has been observed on a number of occasions.

The question arises, why do cryptorchid seals return to the summer breeding ground along with their normal companions? In the presumed absence of sex drive there is no plausible reason for the cryptorchid to leave the oceanic pasture where it has spent half of the year, or more.

Body proportions.—There appear to be various degrees of cryptorchidism in the fur seal. One individual may obviously be a freak while another resembles a normal bull. Five specimens have been arranged in order of decreasing variation from the normal and certain measurements have been recorded for each (Table 1). For purposes of comparison, the measurements of a normal adult male and female have been included. The five cryptorchids are fully adult, as demonstrated by the number of annular growth rings on the teeth.

Table 1 shows that a cryptorchid may resemble a normal bull in the following measurements: length of body, length of hind flipper, and size of skull. It may approach a bull in size of baculum, but not in weight of body and weight of testes. That is, its body is distinctly less robust and its testes are less than one-tenth the size of the bull's. We are interested, and somewhat puzzled, to note that the upper canines or fangs of the cryptorchid are as large as those of the bull. Since the canines of the female seal are much smaller than those of the male, it might be expected that feminism in the

TABLE 1.—Comparative measurements of normal and cryptorchid fur seals

	Adult female	Cryptorchid males					Adult male
Catalog Series	Sitka	BDM	BDM	BDM	VBS	VBS	BDM
Specimen No.	34	202	327	86	1354	1358	298
Body length, cm.	127	173	182	185	188	213	215
Body weight, pounds	102	190	226	222	222	329	613
Hind flipper length, mm.	400[1]	518	510	550	573	558	542
Testes weight, grams	—	—[2]	14	—[2]	13	8	151
Baculum weight, grams	—	1	1	4	6	8	11
Baculum length, mm.	—	76	89	112	131	115	140
Skull weight, grams	204	358	408	540	559	721	653
Condylobasal length, mm.	192	227	235	249	245	245	249
Mastoid width, mm.	94	108	115	122	126	124	131
Upper canine diam., mm.	10	16	15	18	15	16	18[1]
Estimated age, years	10	10	10	15	15	12	15

[1] Estimated after measuring seals of similar size.
[2] Testes not weighed but observed to be infantile.

cryptorchid would be expressed in distinctly smaller teeth, but such is not true. The baculum of the cryptorchid is quite variable in size; in some specimens distinctly subnormal and in others resembling the bull's. Of the two, the cryptorchid baculum is usually the smoother and more slender. With regard to the skeleton as a whole, the bones of the cryptorchid are as long (or even longer) than those of the normal bull but are more slender.

In addition to the skull characters described in Table 1, there are certain others that distinguish the cryptorchid. The sagittal crest, the flaring lamboidal crest, and the elaborate mastoid processes of the adult bull are absent or reduced in the cryptorchid. With respect to these three characters, specimen no. 202 is more like a female than a male. The reduced size of the skull processes in the cryptorchid is reflected in the slender appearance of the head and neck (Fig. 1).

Dentition.—Six of the seven bulls listed in Table 1 have normal dentition, that is, three premolars and three molars in each half of the upper jaw. Cryptorchid specimen No. 1358 has an extra pair of premolars between pairs 2 and 3. Since adventitious teeth are fairly common, this has no special significance.

The upper molariform tooth rows of the fur seal are approximately parallel, although in the male they are arranged thus: ( ), and in the female thus:) (. Our five cryptorchid specimens have the masculine tooth pattern.

In skull No. 86, the second upper molars are missing and the alveoli are filled with bone. Since this pair is normally absent in the Steller sea-lion, we examined No. 86 carefully with the thought that it might be a hybrid, but concluded that it was not.

Pelage.—As much as any other character, the pelage of the cryptorchid is responsible for the popular name "big cow," for the pelage tends to be smooth

in texture and uniform in color, like that of the adult female. The thick, doggy mane of the normal bull is conspicuously absent.

Our attention was called by an islander to a purported "cross between a fur seal and a sea-lion" (*Eumetopias jubata*). This specimen, whose skull (No. 1354) we have saved, proved to be a cryptorchid. The creature was first observed on a beach where fur seals and sea-lions habitually mingle and, for this reason, as well as for the reason that its body was abnormally shaped, we thought it might be a hybrid. On the bases of the flippers the normal brown overhair was present but the dense velvety underfur was entirely absent. The successful mating of a fur seal and a sea-lion has been reported by George Jennison (Proc. Zool. Soc. London, 1914, pp. 219-220). He states that, in captivity, a male "*Otaria pusilla*" [*Arctocephalus pusillus*] and a female "*O. californiana*" [*Zalophus californianus*] produced pups in each of three successive years. In our collection of five cryptorchids we are unable to find characters which point definitely to sea-lion parentage.

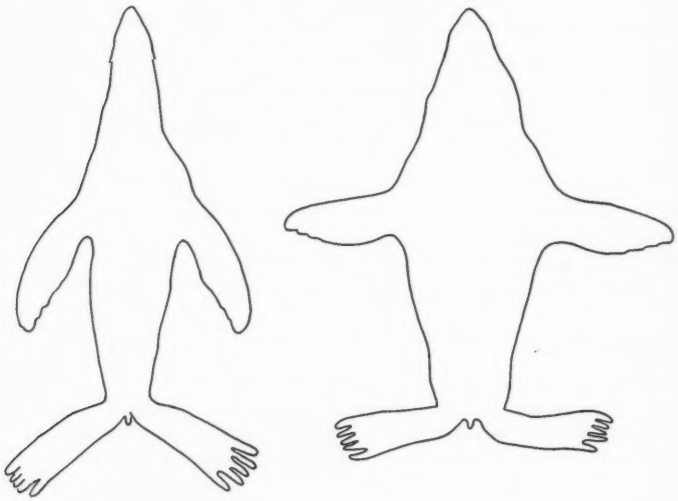

Fig. 1.—Comparison of body proportions of cryptorchid and normal male fur seals. (Left) Cryptorchid; length 188 cm.; weight 222 pounds; age about 15 years. (Right) Normal male; length 191 cm.; weight 405 pounds; known age 8 years. (Traced by projection from photographic negatives.)

Mammal Bones from Dunes South of Lake Michigan

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Introduction

Mammal bones collected in the blow-outs, where the wind is moving away live dunes, give the nucleus of new data for this paper. Present day mammal fauna is compared with the, in part at least, slightly older fauna represented by this dune skeletal material. The area covered is that of the dunes along the south end of Lake Michigan, mostly between Beverly Shores and Dunes Acres (a distance of about 5 miles), in Porter County, Indiana. This includes the area covered by the Indiana Dunes State Park.

These sand dunes are wind made, of sand from the beach of retreating old Lake Chicago, and more recently from Lake Michigan shores. The first or lakeward line of dunes is a nearly continuous ridge, with Mt. Tom, north of Chesterton, the highest point, rising 190 feet above Lake Michigan level. Back of this first ridge, and for various distances up to a mile or so sand ridges run in various directions. The dunes themselves are mostly covered with tree growth, chiefly oak, locally pine (apparently more common formerly), with grass and shrubs covering much of the ground. Outside the Indiana Dunes State Park fires periodically destroy the undergrowth and ground cover. Between the dunes themselves are grassy meadows, swamps and ponds. The wet valley of Silver Creek that cuts through the dunes to enter Lake Michigan carries in places a tall closed deciduous forest. South of the dunes, cultivated fields, woodlots and marshes alternate. (For a discussion of plant communities see Cowles, 1901; and for the flora, Peattie, 1930.)

Though most of the dunes are stable, some of them are live or shifting. New sand continues to be blown up from Lake Michigan, and sections of old dunes are being moved. Where the protective vegetation is destroyed or its cover broken, perhaps by fire, perhaps by an uprooted tree, the wind begins to carry away the sand, inland, to the top of the dune, and drop it on the landward side. This forms a more-or-less semicircular excavation on the lake side of the dune, locally called a blow out. At the same time on the opposite side of the dune a bulging, advancing sand ridge builds up, that smothers the forest and swamp as it advances. In time it may become stabilized and clothed with vegetation. This is a never ending process. For a description of these dunes see Blatchley, 1897.

The blow-outs have steep smooth slopes of loose sand; in places dead trees, long buried, are emerging showing that former, lower forested dunes have been sand covered and are emerging. The dune, being formed of

wind blown sand, moves away in its entirety. Of the vegetation that is uncovered leaves, roots, and small branches disappear, perhaps through decay and wind action, perhaps through the abrasive actions of wind carried sand; only a few larger trunks remain. It is on these slopes of clean, loose sand that the mammal bones, too heavy to be blown away by the wind were found. In effect they have been sifted out of the dune, as the fine sand is blown away. Some of the bones represent mammals that have long since disappeared from the area; some, perhaps of recent origin, are of mammals still extant.

The most recent published survey of the mammals of this area is Lyon's (1936) based in part on collecting trips he made to the dunes, in 1922 (Lyon, 1923) and in 1923 and '24. The complete list of mammals from the Dunes area of Porter County as known to Lyon (1936) and to us from personal knowledge, is given in Table 1. Comparison of collecting results of Lyon's 1922 trip, and of our 1949-50 collecting is also presented separately in Table 1.

Our own mammal studies include casual observations during numerous excursions in the area; a small amount of trapping for small mammals; occasional specimens brought to us since 1947; and most important for this paper, A. S. Rand in the winter of 1949-50, made a series of trips on which the blow outs were systematically searched for mammal bones.

ACKNOWLEDGEMENTS

We wish to express our thanks to the local people who helped to collect the dune skeletal material, notably Thomas W. Pape and Russel Wiemann, and to William Kane who presented us with a collection of material which contained the fisher jaw. We are also much indebted to Mr. Colin C. Sanborn for helping us identify the material in the Chicago Natural History Museum, and for making available to us the record of the dunes skeletal porcupine and the beaver material in that institution.

TYPE OF MATERIAL

Bones were surprisingly common in some blow-outs.[1] Jawbones, or teeth were the identifiable parts most often found, except in the cases of the deer when numerous other bones were found.

The age of the bones obviously varied greatly. Some, such as the deer, bear, elk and fisher we know must be old, having been extinct in this area

1 The abundance of skeletal material is well illustrated by one trip to one blow-out in Dunes State Park in 1951. This was the only collecting trip made this year to this blow-out, that was methodically searched last year.

The material collected by four people searching for about two hours in this one blow-out represented the following species and individuals (based on identification of jaws and teeth): mole, 1; chipmunk, 1; fox squirrel, 1; white-footed mouse, 4; meadow mouse, 2; muskrat, 1; porcupine, 1; cottontail rabbit, 1; Virginia deer, 3 or 4; i.e. 9 species.

for a long time; some, such as the rabbit and microtines are probably very recent, perhaps no more than a year or two old.

Certain old pieces of bone, such as some deer bones were stained brownish and in good condition; others, such as the bear were little stained and very brittle and friable, perhaps due to conditions of burial, wetness of position, and length of time spent in the dry, actively shifting sand or on its surface. Rabbit bones, probably not old, were always badly broken and very fragile.

PROBABLE METHODS OF DEPOSITION

The most obvious of the possible ways in which this skeletal material found its way into the blowouts are:

1. A dead animal, or its parts, buried under a live dune and later exposed in the blowout. The position of the bear skull indicates this may have applied to it.[2]

2. Transported by humans to one place in the dunes for food. The abundance of deer remains in the large blowout in the State Park known as the Beach House Blow-out, coupled with the presence of fire-blackened Indian cooking stoves suggest this correlation with deer. Modern man's contribution seems limited to chicken, steak and chop bones which are disregarded in this study.

3. The animal had died recently on or near the blowout, and the remains had slipped to their present position from the surface,, rather than from a buried position. It is possible some of the smaller rodents and the mole bones were so deposited.

4. Carnivorous birds or mammals may have caught small rodents at some distance and carried them to commanding positions near the blowout to eat, or have regurgitated pellets containing mammal bones. One pellet containing mice jaw bones was actually picked up.

5. A skunk skull picked up on a dunes trail, possibly from a hunter-killed animal, suggests a further possibility.

COMMENTS ON THE SPECIES REPRESENTED

Of the 47 species of recent mammals recorded from the dunes area by Lyon and ourselves, we have seen dune skeletal material of 21. Of these, 6

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[2] This probably applies to a further deer find in 1951 also. Excavation below fragments of deer bones resting on the surface revealed five lumbar vertebrae, parts of the pelvis, several ribs, and several leg bones buried in the sand within 8 inches of the surface, in an area about 5 feet across. The vertebrae and part of the pelvis were still articulated; the other bones were scattered and broken.

species have been exterminated a long time in the area: bear, fisher, beaver, porcupine, elk and deer (though beaver and deer have been recently reintroduced). An additional seven species once occurring but not now known in the area were not found: otter, coyote, wolf, cougar, lynx, wildcat and bison. Of the six extinct species of which we have seen material, the fisher seems to be the first specimen recorded for Indiana, to support the few old published records of its occurrence; the elk antler provides the first record for Porter County; the bear provides the first record for Porter County. The abundance of deer bones is striking, attesting its early abundance, and perhaps its use by Indians for food.

It is possible that continued searching will yield skeletal material of the other extinct species recorded from the area, and there is the possibility that other, unrecorded species may be found, such as the varying hare.

A number of the mammals known from Indiana, notably deer, elk and fisher are represented by too scant material for taxonomic work. Possibly the accumulation of additional dunes material may be of value in this connection. Lyon (1936) lists a number of Pleistocene species under the same specific name as the present day forms, notably bison, deer, elk, coyote, and bear. Possibly as material accumulates from the dunes blowouts, and Pleistocene material also accumulates, a study of the two would prove of interest.

Several points emerge from a survey of the species still extant. The complete absence of such fairly large, common species as the skunk and opossum is noteworthy. The occurrence of chipmunk and ground squirrel remains, species that are comparatively rare, in as great numbers as the commoner red and fox squirrel is also unexpected.

Certain species represented in the dune skeletal material reflect an earlier element in the fauna that has since withdrawn, such as deer, elk and fisher. Certain others, such as the chipmunk and ground squirrel may indicate a change in status. The absence of such species as the opossum and skunk in our collection might suggest a recent emigration.

The presence of house rat bones in the material indicates that the dune skeletal material definitely is not all old, and is probably still being added to.

The material collected that seems of permanent value will be deposited in the Chicago Natural History Museum.

The importance of this type of collecting is indicated by comparing the dunes skeletal material wtih the result of Lyon's 1922 collecting trip. Lyons secured 22 species of mammals; species picked up by us represent 19 species, 6 of which Lyon did not secure on his collecting trip.

In the following list specific names only are used.

Table Showing Mammals Recorded for Porter County

	Lyon's 1936 Porter County records	Occurrence known from personal records (including dune skeletal material)	Species known from dune skeletal material	Species recorded by Lyon in his 1922 brief field trip	Minimum number of individuals represented in dune skeletal material
Family DIDELPHIIDAE					
1 Didelphis virginiana	×	×	–	×	
Family TALPIDAE					
2 Scalopus aquaticus	×	×	×	?	1
Family SORICIDAE					
3 Sorex cinereus	×	×	–	–	
4 Cryptotis parva	×	–	–	–	
5 Blarina brevicauda	×	×	–	×	
Family VESPERTILIONIDAE					
6 Lasionycteris noctivagans	×	×	–	–	
7 Eptesicus fuscus	–	×	–	–	
8 Lasiurus borealis	×	×	–	×	
Family URSIDAE					
9 Euarctos americanus*	×	×	×	–	1
Family PROCYONIDAE					
10 Procyon lotor	×	×	×	×	2
Family MUSTELIDAE					
11 Martes pennanti*	–	×	×	–	1
12 Mustela rixosa	–	×	–	–	
13 Mustela frenata	×	×	×	×	2
14 Mustela vison	×	×	–	×	
15 Lutra canadensis*	×	–	–	–	
16 Mephitis nigra	×	×	–	×	
17 Taxidea taxus	×	–	–	–	
Family CANIDAE					
18 Vulpes fulva	×	–	–	×	
19 Canis latrans*	×	–	–	?	
20 Canis lupus*	×	–	?	?	?
21 Felis concolor*	×	–	–	–	
22 Lynx canadensis*	×	–	–	–	
23 Lynx rufus*	×	–	–	–	
Family SCIURIDAE					
24 Marmota monax	×	×	×	×	22
25 Citellus tridecemlineatus	×	×	×	×	2
26 Citellus franklini	×	×	–	–	
27 Tamias striatus	×	×	×	×	3
28 Tamiasciurus hudsonicus	×	×	×	×	1
29 Sciurus carolinensis	×	–	–	–	
30 Sciurus niger	×	×	×	×	1
31 Glaucomys volans	–	×	×	–	1
Family CASTORIDAE					
32 Castor canadensis*1	×	×	×	–	13

Table Showing Mammals Recorded for Porter County—(*continued*)

	Lyon's 1936 Porter County records	Occurrence known from personal records (including dune skeletal material)	Species known from dune skeletal material	Species recorded by Lyon in his 1922 brief field trip	Minimum number of individuals represented in dune skeletal material
Family CRICETIDAE					
33 Peromyscus maniculatus	×	×	×	×	5
34 Peromyscus leucopus	×	×		×	
Subfamily MICROTINAE					
35 Synaptomys cooperi	×	×	×	–	2
36 Microtus pennsylvanicus	×	×	×	–	5
37 Microtus ochrogaster	×	–		×	
38 Pitymys pinetorum	×	–		×	
39 Ondatra zibethica	×	×	×	×	4
Family MURIDAE					
40 Rattus norvegicus	×	×	×	×	2
41 Mus musculus	×	×	–	×	
Family ZAPODIDAE					
42 Zapus hudsonicus	×	–	–	–	
Family ERETHIZONTIDAE					
43 Erethizon dorsatum*	×	×	×	–	13
Family LEPORIDAE					
44 Sylvilagus floridanus	×	×	×	×	6
Family CERVIDAE					
45 Cervus canadensis*	–	×	×	–	1
46 Odocoileus virginianus*1	×	×	×	×	5+
Family BOVIDAE					
47 Bison bison*	×	–	–	–	

* Species exterminated in the area. 1 Reintroduced. 2 Also 1 skull picked up by Lyon. 3 Specimen in C. N. H. M.

ANNOTATED LIST OF SPECIES

Family DIDELPHIIDAE

One species, the Virginia opossum is common in the area and its non-occurrence in the dune skeletal collection is noteworthy.

Family TALPIDAE

Skeletal material of the single species of mole occurring is given below:

Scalopus aquaticus (Linnaeus), Prairie Mole.—Just south of the dunes the prairie mole is common, and its tunnelling in lawns a nuisance. We have seen a number of specimens taken in mole traps in such situations, and others caught by domestic cats. We had attributed the numerous mole-like, raised burrows seen in the dunes to this species, but Lyons (1923, pp. 212, 218) was unable to secure any mole specimen in the dunes, and tentatively referred these burrows to the pine mouse (*Pitymys*).

Dune skeletal material includes: 1 mandible and 1 anterior part of a skull with both tooth rows. Though the bones were collected at different times, perhaps only one animal is represented.

Family SORICIDAE

None of the three species of shrews was found in the dunes skeletal material, not surprising in view of the small size and relative scarcity of the animals.

Family VESPERTILIONIDAE

Lyon (1936) recorded but two species of bats for Porter County. We have added a third, the big brown bat *Eptesicus fuscus*, of which we have handled specimens. However, bats are not common, and one would hardly expect their frail remains to occur with any frequency in dune skeletal material.

Family URSIDAE

Euarctos americanus (Pallas), Black Bear.—The status of the now extinct black bear in Porter County as given by Lyon rests on Brennan's 1923 hearsay evidence of its former occurrence. In northern Indiana the latest records of the black bear for adjacent Lake County is 1850 and for La Porte County 1835 (Lyon, 1936, p. 92).

The skeletal material found in the dunes thus assumes interest as a specimen corroborating occurrence. It consists of an incomplete skull with one complete maxillary tooth row and one incomplete one. From the amount of wear on the teeth it represents a young adult. Though considerably perished, the bone has little brown stain on it. It seems probable this material is more than 100 years old. It was found under a fallen dead tree of a forest that had been smothered by an advancing line dune and is now nearly uncovered. The skull parts were recovered on two different trips, but fit together indicating but one animal is involved.[3]

Family PROCYONIDAE

Procyon lotor (Linnaeus), Raccoon.—Raccoons are common throughout northern Porter County, are occasionally seen in the rays of car headlights, and their tracks can usually be found in almost any suitable place, including the dunes themselves. It is probably somewhat more common than the opossum. Thus it is surprising that Lyon, on his 1922 trip, had no personal records of this species and perhaps indicates it was less common then.

Dune skeletal material includes 1 maxillary fragment with molar; and several maxillary and mandibular fragments with teeth. Two animals are probably represented. One lot of 9 fragments came from a black stratum of sand containing vegetable matter, indicating some age, as does the general condition of the bone which resembles that of the bear bones.

Family MUSTELIDAE

Lyon (1936) recorded 5 species of the weasel family from Porter County. To this list we have added 2, one from dunes skeletal material (the fisher, see below) and the Least Weasel. A single live individual of the Least Weasel was brought to us by Dean Colley of Porter who caught it just south of the dunes in Porter on June 10, 1950. The skunk, though common in the dunes area and often commonly seen on trails in the evening, was not represented in dune skeletal material.

Martes pennanti (Erxleben).—Lyon had 3 published records of the fisher, from the central and southern part of the state, dated 1820, 1833, and 1859. Apparently, no specimen exists from Indiana.

Skeletal dunes material consists of an incomplete right mandibular ramus with canine in place and sockets for four teeth and anterior root of fifth. It checks well with the corresponding part of a male fisher in the Chicago Natural History Museum. This

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3 In 1951 Mr. Peter B. Nicholson of Gary, Indiana, presented us with a nearly complete bear skull without mandibles that he had picked up in the dunes near what is now the mouth of Burns Ditch, in 1919.

specimen came from Bill Kane, and we know nothing more of its origin than that it came from a blow out in the dunes. The bone is old and perished, but has little brown stain on it. It is probably more than 100 years old.

Mustela frenata Lichtenstein, New York Weasel.—The New York Weasel as Lyon says (1923, p. 213) is not uncommon in the dunes area, and we have seen two individuals, in summer, in the daytime in the dunes area.

Dunes skeletal material: 1 left mandible ramus with teeth and 1 right mandible ramus with teeth. One mandible is slightly heavier than the other, indicating the remains of two individuals. Both appear to be of no great age.

Family CANIDAE

Of the three species Lyon recorded for Porter County, there is dune skeletal material for one as given below. Though we have seen no foxes, locally fox hunts are held in winter and a few red foxes are said to be taken.

Canis lupus Linnaeus, Wolf.— The wolf has long been extinct in this area, and while we have no data, the species is mentioned here to call attention to part of a jaw, picked up by Lyon, associated with deer bones in a blowout, that could have been remains of a wolf (Lyon, 1923, p. 212).

Family SCIURIDAE

Lyon recorded seven species for Porter County. We have added one, the flying squirrel (see below). Six of the eight known species are represented in dune skeletal material.

Marmota monax (Linnaeus) Woodchuck.—Lyon in 1922 found woodchucks very common almost everywhere in wooded portions of the dunes as judged by their many burrows (1923, p. 219). In our experience the woodchuck is decidedly uncommon in the dunes area, and still more so in the country immediately to the south, about Chesterton. We have seen but 3 or 4 animals in the whole area. We have found their burrows only in the dunes, where they were scarce.

Dune skeletal material: 1 left mandibular ramus, of no great age. Lyon also picked up a weathered skull in the Furnessville blowout (1923, p. 219).

Citellus tridecemlineatus (Mitchill), Thirteen-lined Ground Squirrel.—Lyon in 1922 found this animal not uncommon along the South Shore Railroad and recorded it in the dune themselves (1923, p. 218). He suggests it may have entered this region along the railroad from its original home in the natural prairie of the west. Its abundance in northern Indiana he indicates by saying that every motorist has seen it dart across the road (1936, p. 180) and "is seen running across roads everywhere" (p. 187).

In our experience the animal is scarce. There are a few places where one or a few animals may be found, and occasionally single animals appear almost anywhere, including one on the Chesterton school grounds.

Dune skeletal material include: Anterior part of a skull including tooth rows; 1 mandible and a fragmentary mandibular ramus. The bone appears recent. Probably two animals are represented.

Tamias striatus (Linnaeus), Chipmunk.—Lyon (1923, p. 191) records the chipmunk as not very common in the dunes area, and speaks of seeing several.

We have seen but a single chipmunk in our field work. It was running over the sand on the edge of a blowout.

In view of the few records of occurrence, the number of bones in the dune skeletal material is surprising. They include 5 mandibular rami. Four are in good condition and not old. The fifth is fragmentary. At least 3 animals are represented, and probably 4 or even 5.

Tamiasciurus hudsonicus (Erxleben), Red Squirrel.—The red squirrel is fairly common in the wooded dunes, as it is in the woodlots and in Chesterton itself. The dunes skeletal material, however, includes but a single mandibular ramus without teeth.

Sciurus niger Linnaeus, Fox Squirrel.—Fairly common throughout in wooded areas, the fox squirrel is hunted and is shy. Its tracks in the sand indicate it is commoner than the number of animals seen would indicate. The dune skeletal material includes a fragmentary mandibular ramus without teeth. Also possibly referable to this species are 3 upper incisors and 2 lower incisors.

Glaucomys volans (Linnaeus), Flying Squirrel.—Though Lyon (1936, p. 213) had no record of the flying squirrel for Porter County we have seen several specimens from just inside the dunes as well as from Chesterton and the species is probably not uncommon in the area. The dunes skeletal material consists of 1 mandibular ramus with teeth.

Family CASTORIDAE

Castor canadensis Kuhl, Beaver.—Beaver have long been exterminated in Porter County. A single incomplete skull picked up in a blowout at Ogden Dunes, now in the Chicago Natural History Museum, and reported by Lyon (1936, pp. 222, 226) was the only Indiana specimen he knew.[4]

Within the last few years the State Conservation Department has introduced beaver into the marshes just south of the dunes at Baileytown and in 1950 a thriving colony was established. The dam, across a drainage ditch, flooded considerable marsh land and caused complains by local residents. The state has attempted to remove them; and is said to have been partly successful. Some future records of beaver for this area may be the result of their introduction.

Family CRICETIDAE

The small size of most of the species, and the fragmentary nature of the material representing them has made identification difficult. Quite possibly the actions of predators have been a factor in depositing their bones, as for instance, in owl pellets, in the blowouts.

Peromyscus, White-footed Mice.—Both species, *P. maniculatus* and *P. leucopus* occur commonly in this area. The former occurs most commonly in the fore dunes along the lake where the latter is absent (Lyon, 1923, pp. 214, 215).

The dune skeletal material includes 8 mandibular rami mostly without teeth, 5 left and 3 right, not identified as to species. This means at least 5 animals are represented.

Subfamily MICROTINAE

Synaptomys cooperi Baird, Lemming Mouse.—Though recorded from Porter County (Lyon, 1936, p. 253) Lyon did not find it in the dunes on his trip in 1922 (Lyon, 1923). We have secured no specimens but the dunes skeletal material includes 2 fragmentary left mandibular rami with some teeth, evidently representing 2 animals.

Microtines.—Three species: Pennsylvania Meadow Mouse, *Microtus pennsylvanicus;* Prairie Meadow Mouse, *Microtus ochrogaster;* and the Pine Mouse, *Pitymys pinetorum*—occur in northern Porter County.

Dunes skeletal material not identified to species includes 7 mandibular rami and 1 anterior part of a skull. Skeletal material is all much weathered and broken. At least 5, and perhaps more animals are represented. Microtine skull parts were also found in the droppings of large carnivore, indicating how some of the smaller mammal bones come to be deposited in the dunes.

Ondatra zibethica (Linnaeus), Muskrat.—Muskrats are present throughout the area in suitable marshes where they are heavily trapped.

Dune skeletal material includes 3 skulls of varying completeness, 4 mandibular rami, and two single grinding teeth. The age and conditions of these varies greatly; some are

4 We have also received a piece of beaver molar picked up in the dunes by Bill Kane.

old, brown, others white and fairly fresh-appearing. Probably 4 or 5 individuals are represented.

Family MURIDAE

The presence of one of the two introduced members of this family in dunes skeletal material demonstrates that such material is not necessarily of any great age.

Rattus norvegicus (Erxleben), Norway Rat.—This rat is common about settlements. Lyon (1923, p. 218) suggested that with greater population Norway rats will become a constant part of the dune fauna.

Dune skeletal material includes: anterior half of a skull and 1 broken mandible probably representing 2 mammals.

Family ERETHIZONTIDAE

Erethizon dorsatum (Linnaeus) Porcupine.—The porcupine formerly occurred over a considerable part of Indiana but Lyon (p. 936, p. 285) considered it extinct, with the latest record in 1918 in northern Porter County.

Dune skeletal material includes: 1 left mandibular ramus found in a blow-out in the Dunes State Park by Jay Thomas and T. W. Pape. Though slightly stained brown, it does not appear of any great age.[5]

Family LEPORIDAE

Unconfirmed records of the varying hare (*Lepus americanus*) exist for northern Indiana (Lyon, 1936, p. 288), but the only species known to occur is the following:

Sylvilagus floridanus Allen, Cottontail.—Cottontails are common generally but less so in the dunes than in the country just to the south where there is more succulent vegetation.

Dunes skeletal material includes 8 upper tooth rows; 7 fragmentary mandibular rami, 5 right, 2 left; 2 upper incisors; and 1 lower incisor.

All these are fragmentary, these skulls apparently breaking up quickly. Probably 6 or more animals are represented.

Family CERVIDAE

Two recent species are known, both exterminated; both known from dune skeletal material, and both also known from the Pleistocene.

Cervus canadensis (Erxleben), Elk.—Lyon records Pleistocene elk specimens for the counties Lake and La Porte, immediately to the east and west of Porter County, and an old record of its occurrence in the Kankakee Valley. It has probably been exterminated in the state for more than 100 years, Lyon's most recent date of occurrence being 1830.

Dune skeletal material: the basal part of an antler. The approximate circumference above the burr is 8½ inches; 2 tines are present; the over-all length of the remaining portion of the beam is about 21 inches long.

Odocoileus virginianus (Boddaert), White-tailed deer.—The deer has been exterminated and re-introduced. Lyon (1936, p. 309) says deer were fairly numerous in Porter County about 1875, and being killed off shortly after. Lyon (1923, p. 220) recorded deer remains in the dunes, including teeth, antlers, and a pelvis.

Our dune material includes 73 cheek teeth, mostly single; also 2 nearly perfect mandibular rami[6] with teeth in place, in addition to 3 incomplete antlers, many vertebrae, long bones, toe bones, ribs and parts of pelvis that probably belong to this species.

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5 In 1951 we picked up, in a blow-out in the Dunes State Park, part of a porcupine skull with five maxillary molars in place.

6 In 1951 three more mandibular rami were picked up in Dunes State Park, and three others were seen in the possession of other persons.

The condition varies from fragile, unstained, weathered and broken-up pieces of bone to heavily brown-stained, well-preserved bones.

The condition of the teeth indicates that most of the animals represented were young to young adults. There is only one very worn tooth.

In the blow-out in the Dunes Park known as the Beach House Blow-out where deer bones are especially common there are many Indian cooking stones, suggesting that the Indians brought the deer to a camp. None of the positively identified deer bones are fire blackened, and the only burned bones found at all were two charred fragments that might have been deer.

In recent years deer have been re-introduced into the dunes area by the Indiana Conservation Commission, according to local report. Now it is usual to see deer tracks on the park trails. Occasionally a deer is reported elsewhere in the nearby country.

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The Formation and Function of Mucoids in Virgulate Cercariae, Including a Study of the Virgula Organ*

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In the course of a preliminary study of xiphidiocercariae from *Goniobasis livescens* Menke (1830) collected from the Huron River near Ann Arbor, Michigan, it was noted that the cercariae could be divided into two groups by the presence or absence of a virgula. About ten species of virgulate cercariae were distinguished and, at the suggestion of Professor G. R. LaRue, a further study of the virgula, a peculiarly shaped organ lying within the oral suckers of the cercariae was undertaken.

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Historical Review.—The virgula was first described by Filippi (1857) in *Cercaria virgula* as bilateral, glandular, flask-like organs in the anterior sucker, inferior to the mouth cavity. Lühe (1909) created the group *Cercariae virgulae* to include the five species of cercariae known to possess this structure. Sewell (1922) subdivided Lühe's *Cercariae virgulae* into three groups and described two morphological types of virgulae, one saccular and the other more or less rod-like and closely associated with the buccal cavity. Sewell noted in two of the species described by him that the appearance of the virgula organ was sudden and correlated, during a "metamorphosis," with the disappearance of certain transient glands. He further thought the virgula to be a hollow organ and suggested that it acted as a supporting structure for the oral sucker during penetration. Porter (1938) agreed with Sewell's interpretation. Dubois (1929) described glands similar to those noted by Sewell as sub-cuticular cystogenous glands. Wesenberg-Lund (1934) described the virgula organ as consisting of a refractive substance and hollow with an unknown function.

Yamaguti (1938) noted that the virgula of *Loxogenes liberum* Seno disappeared shortly after the cercariae had penetrated into their second intermediate host and assumed from this that it must "play an important part during the act of penetration." Seitner (1945) noted an "oily" virgulate secretion which stained orange or salmon color with neutral red. The latter decided that the glandular discharge was not "essential to the penetration of the intermediate host" since the virgula persisted in "young metacercariae." He was unable to decide whether the virgulae are contained within the oral suckers of the cercariae or merely crowded against them.

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* Contribution from the Zoology Departments of the University of Michigan and the University of Illinois.

Structure of the virgula.—Determination of the precise structure of the virgula is rendered difficult by its amorphous appearance, the normal translucency of its contents, and their poor affinity for many stains. Only carefully controlled fixation, dehydration, and clearing prevent distortions of the cercariae that limit the values of whole mounts. Many *intra-vitam* dyes stain the cercariae well, and neutral red and Nile blue sulfate, particularly, color the virgula differentially after long application in great dilutions; but it is difficult to secure the necessary partial immobilization of living cercariae without proportional distortion of the virgulae. Specimens killed and progressively stained with Schneider's aceto-carmine and slowly cleared *in situ* by increasing the concentration of glycerin yield good material for study; this treament induces a slight swelling of the virgula which makes its ducts more clearly visible. The contents of the virgula are solidified or gelled by the acetic acid in this stain and remain almost clear in contrast to the bodies of the cercariae. Individual specimens so prepared can be manipulated by careful movements of the cover glass and single virgulae thus studied from various angles. Mayer's haematoxylin and Heidenhain's azan triple stain used on serial sections of formalin fixed, normally emerged cercariae differentiate the tissues of the oral sucker well, but the contents of the virgulae stain very lightly or are lost.

The oral sucker of the virgulate cercariae studied is delimited from the general body tissues by a definite membrane, reinforced by closely associated muscle fibers. That portion which lines the buccal cavity is much less strongly reinforced, only a few scattered fibers being available to constrict the mouth. The most prominent feature of the oral sucker is the characteristic stylet in its anterior, median portion. The musculature of the stylet is prominent and consists of very heavy fibers that originate along the antero-lateral portion of the limiting membrane of the oral sucker and attach to the base of the stylet (Figs. 5-8, 25-27). No other fibers of this caliber are found in the oral sucker. The remainder of the sucker is in an unorganized state. Nuclei surrounding the virgulae are highly compressed. In cercariae with large virgulae the suckers are correspondingly enlarged but other tissue elements do not appear to be increased over those found in much smaller suckers. Nuclei present presumably include those associated with stylet and weak musculatures and probably with nervous elements. No cells are found within the oral sucker at any time during the lives of these cercariae that can be considered responsible for the development of the virgula organ or the formation of its contents. The comparatively disorganized state of the tissues of the oral sucker are surprising in view of the adhesive activity of the oral sucker observed in the present studies and noted by Porter (1938).

In the species observed, virgulae are typically paired, bilaterally symmetrical organs, enclosed by very delicate limiting membranes. They are closely associated with the buccal cavity. No membrane other than that surrounding the virgula proper can be seen separating the virgulae from adjacent compressed sucker tissues and flattened nuclei. Neither the tissues of the oral sucker nor its limiting membrane can be found between the virgula organ

and the chromophilic buccal cuticula. Therefore the virgula is most properly considered as an organ contained within the oral sucker, not as a structure simply crowded against it, alternatives suggested by Seitner (1945).

Within a species the virgula has a constant shape and size; but between different species this organ presents considerable variation (Figs. 1, 12, 16-24 incl., 36, 37, 38, 41). The simplest virgulae are sac-like structures that originate morphologically as slender strands along the ventral surface of the buccal cavity, enlarge distally in the oral sucker and terminate in minute dorsal pores within the buccal cavity, rather deep in some species, but at the lip region in others.

In much more complex forms, the virgulae outline the mouth cavity closely (see also Dubois, 1929; Pl. XII, fig. 83) and consist of swollen, winding tubes that originate near the ventral lip of the mouth, run caudally to the postero-inferior region of the oral sucker, then, bending back on themselves in the form of a close "U", run anteriad to the level of their origin where they may loop laterally before terminating near the dorsal lip of the oral sucker (Fig. 20). Lateral alae of the buccal cavity, not intrinsic parts of the virgulae, but distorted by them, extend into or through the surrounding, closely adherent, looped tubes and impart the "hollow" appearance noted by Sewell (1922) and Wesenberg-Lund (1934).

In some species the virgula appears quadripartite, each bilateral structure consisting of two unequal parts that open separately into the buccal cavity. A shorter portion, difficult to differentiate, is obscured by the larger, and simulates a diverticulum of the latter. The presence in the buccal cavity of a hyaline coating of material similar to the virgula secretion, and stemming in part from it, masks the virgula pores; the extrusion of this coating of material from the buccal cavity gives the false impression of pores located on the edge of that cavity.

In all species the virgula alters progressively after emergence of the cercariae, so that only freshly emerged cercariae possess unmodified virgulae. Occasionally the virgula disappears almost completely, so that only minute remnants persist requiring care to demonstrate (Fig. 43). In species with very large, full virgulae, portions of the originally paired organs press closely together, rupturing separating tissues to become confluent along the midline. In such specimens the virgulae also constrict the buccal cavity to a very shallow pit, occasionally break through lining cuticula, and form accessory pouches opening into the buccal cavity through the cuticula by broad secondary foramina.

Various factors may contribute to this tendency to coalesce. In living specimens, the hydration of virgulate contents causes swelling without similar compensatory enlargement of the oral sucker, thus causing them to crowd together, past the rupture point of intervening tissues. In serial sections of cercariae of increasing emerged age a progressive swelling of all cells of the body is detectable and is most probably due to an influx of water. Water imbalance of some degree during a temporary, free existence, is predictable

in animals that are endo-parasitic for the greater part of their lives. Cercariae develop within molluscs and may remain for some time in the tissue spaces of their hosts. Emergence is followed by a variable, but comparatively short, free existence. They may encyst immediately or enter a second host to which their adaptation is unquestionable. As adults, trematodes usually inhabit a different host, without an intervening free life. Thus their adaptability is variable, but their normal habitat is parasitic and their surroundings must approach isotonicity with them. Their lack of adaptation to free life is shown by the inability of cercariae to feed and their short life in the aquatic environment.

Imbibition of water from a hypotonic medium in excess of the ability of protonephridia to eliminate exerts intertissue pressures that thus cause, first, apparent "normal" discharge of virgulate contents, and second, the rupture of virgula membranes as noted above.

Technical manipulations accentuate various changes in virgulae. Fixation in corrosive sublimate subjects virgulae to constricting forces from shrinking cercarial tissues and might cause abnormal virgular discharge. Formalin fixes tissues of cercariae with less shrinkage but permits progressive hydration and enlargement of virgula contents with consequent excessive distortions of the virgula organs and the containing sucker tissues. Improper dehydration distorts the relations of virgula and oral sucker, producing unpredictable artifacts in whole mounts. In serial sections of non-emerged cercariae *in situ* a much larger buccal cavity and more definite septa separating the paired virgulae were observed than is found in similar sections of emerged specimens of the identical species.

Nature of the contents of virgulae.—Evidence of the more exact nature of the virgula secretion is found in its affinity for special dyes and its chemical reactions. A series of techniques designed to differentiate mucoid secretions were successfully attempted on the virgulae of cercariae fixed for several days in 10% formalin. Mucicarmine, correctly handled, is highly selective for mucins and stains virgulae a deep red, cercarial tissues slightly or not at all. It cannot be modified to stain general tissues well without a loss of its value as a mucin indicator. A trace of sodium bicarbonate produces the basicity necessary to differentiate mucins. An excess of this reagent causes the formation of a red gelatinous precipitate of aluminum hydroxide which is colored by the carmine, blanketing the parasites and destroying the effectiveness of the stain. Slightly acid solutions of mucicarmine change its activity so that tissues stain well but the selectivity of the stain is lost. Mayer's muchematin stains the bodies of cercariae blue, but stains virgulae much more intensely. It is thus adequate for the differentiation of known mucoid substances but the necessity for careful control of the stain level decreases its value as a differential test for unknown compounds or suspected mucoids.

Various metachromatic stains were also employed for the differentiation of mucin. These included Grübler's toluidine blue, and toluidine blue O, methylene blue, neutral red, and thionin. Neutral red differentiates the

virgulae of living cercariae well. They stain an orange or salmon red in contrast to the deep red of other cercarial tissues, a definite indication of the mucoid nature of virgula secretions. This color differentiation is more difficult to obtain in neutral red preparations of entire specimens fixed in formalin or $HgCl_2$ but dilute aqueous solutions of the stain are highly selective for virgula secretions. Methylene blue seems least satisfactory so far as differentiation is concerned although it stains virgulae deeply. Toluidine blue and thionin are excellent for sectioned material; toluidine blue is less satisfactory than thionin for mounts of entire specimens because of its greater sensitivity to the decolorizing and reversing activity of alcoholic dehydration; but it differentiates them much better than the other stains. Aqueous thionin and toluidine blue stain cercariae blue, virgulae bright red to purple-black depending on intensity of stain. Very dilute thionin shows greater selectivity for mucin and stains only the virgulae, but appears to lose its affinity for secretions after long fixation of specimens in sublimate acetic.

Fixation or storage in fixatives beyond several days changes the affinity of the mucin for mucicarmine and muchematin, but apparently does not alter the reaction to thionin. Cercariae fixed in saturated aqueous corrosive sublimate stained poorly in mucicarmine and muchematin, but reacted well with thionin. Fixation in Ripart and Petits' solution of copper acetate, copper chloride and acetic acid in camphor water, followed by dilute methyl green in Ripart and Petits' solution did not stain the bodies of cercariae, but colored the virgulae a brilliant green. The last technique was designed especially by its originators to demonstrate mucins produced by invertebrates.

Specimens were stained successively with Harris' hematoxylin and Mayer's mucicarmine to demonstrate the general structures of cercariae as well as those of the virgulae. Care must be used in the employment of the latter technique because mineral acid solutions, such as hydrochloric acid used for decolorizing, hydrolize virgulae and destroy their affinity for mucicarmine. Overstaining with hematoxylin and subsequent destaining in either aqueous or alcoholic hydrochloric acid followed by a basic neutralizing agent such as potassium acetate or lithium carbonate so changes the nature of the mucin that the virgulae react only faintly, if at all, with special stains. Variation in concentration of acid and of basic neutralizing solutions, as well as duration in any given concentration, appears to produce variations in affinity of virgulae for the differential stains. Long exposure to relatively concentrated solutions results in a complete destruction of staining quality of virgulae; while after short treatments in mild solutions the virgulae still retain chromotropic qualities.

Reactions with reagents employed in the preceding techniques provide further evidence that the virgulae contain mucin. As reported in the literature, the reactions of the numerous mucins or mucoid compounds in the liberal or older, less restricted sense of those terms, vary widely. In general they hydrate to form slimy viscous substances, can be precipitated by weak organic acids such as acetic, and hydrolize into their respective protein and carbohydrate components when treated with mineral acids and, in most

instances, by solutions of bases. Thus mucin precipitated by acetic acid can be dissolved readily in alkaline or/and neutral salt solution.

The precipitation effect of acetic acid on the contents of the virgulae was readily demonstrated during the use of Schneider's aceto-carmine and of Ripart and Petit's technique. The virgulae dissected from specimens treated as discussed for those techniques were solidified but remained translucent, an indication of their finely gelatinous nature. The loss of stain affinity by virgulae subjected to the successive hydrochloric acid and basic solutions of the Harris' haematoxylin technique is probably caused by hydrolysis, certainly by a change in their fundamental nature.

The loss of ability of virgulae to stain with mucicarmine after several days' exposure to 10% formalin may be explained variously. The formalin used was not neutralized and free acids, their presence confirmed by phenolphthalein titration, may have gradually and partly hydrolized the mucins and destroyed their affinities for mucicarmine. The formalin may have combined with the mucins, in a sense denaturing them, and thus changed their reaction to this stain. Or, finally, the formalin may not have affected the mucins directly, allowing them to react with the water of solution in a hydrolytic reaction. Tremendous swelling of the virgulae occurs in cercariae allowed to remain in formalin solutions for comparatively short periods. Specimens appeared to react normally, however, after prolonged fixation in 10% formalin when exposed to dilute thionin solutions.

In further tests to determine more specifically the action of acids and bases on the virgula, thionin was chosen as a mucin indicator because of its strong differential reaction despite unfavorable conditions and possibly less specific substrates. Virgulae of permanent mounts of formalin fixed, unstained, specimens, placed in 1% aqueous HCl at room temperature for two days, were still metachromatic; those exposed to the same solution at 75°C. for several hours showed complete degeneration of mucin. Similarly, virgulae exhibited a complete loss of affinity for thionin after exposure to 25% aqueous HCl for several days. The reaction of cercarial tissues to thionin was changed, but they remained stainable. Mucin collected from the respiratory tract of a vertebrate reacted similarly. It hydrolized slowly in cold dilute aqueous solutions of HCl but reacted more readily in hot or more concentrated solutions; very viscous solutions resulted from the latter experiments.

The virgulae of cercariae fixed in 10% formalin for a short time and treated with concentrated aqueous potassium acetate at room temperature and at 75°C. showed no change in stainability. Similarly fixed cercariae, and others fixed in 70% alcohol and 3% acetic acid, placed in aqueous solutions of potassium hydroxide varying in concentration from 1% to 10% at room temperature for 11 hours, showed proportional marked increase in volume of the still highly metachromatic virgula organ. The ducts leading from virgulae to oral cavity ruptured and mucin from the virgulae extruded into and through the buccal cavity dispersing around the anterior ends of the cercariae.

In some instances virgulae ruptured through the body walls of the cercariae. The swelling of virgulae in solutions of bases is similar to that observed in cercariae allowed to remain in 10% formalin for several weeks. It thus is possible that absorption of water from the medium occurs during initial mucoid breakdown. Once the swelling processes have ruptured surrounding tissues, final mucoid breakdown follows more readily.

To investigate further the action of weak hydroxyl compounds, formalin fixed cercariae were placed in dilute solutions of calcium and barium hydroxide, reagents frequently used in the initial isolation of various mucoid complexes. In dilute solutions, no visible change in virgula contents and metachromatic stainability was observed. Similarly no alteration in thionin metachromasy was observable in the virgulae of cercariae treated with saturated solutions of calcium hydroxide for more than eight hours at 75°C. One portion of these cercariae was heavily stained, then exposed to 1% aqueous HCl until virgulae and tissues were clearly differentiated to red-purple and blue respectively. When placed in aqueous potassium acetate their virgulae destained very rapidly. A second lot of the treated cercariae was placed in strong aqueous potassium acetate at room temperature for several days, then tested with thionin. Before dehydration, virgulae were metachromatic red. Some of the virgulae of this group retained only a very light blue stain through alcoholic dehydration and others showed no reaction. Thus, the metachromatic affinities were not sufficient to persist through the very rapid alcoholic dehydration employed in all of these experiments, indicating an action of potassium acetate on the calcium hydroxide treated virgulae.

These reactions of virgulae to various chemicals are not conclusive evidence of the nature of their contents. They only tend to confirm the indications obtained by the employment of special dye techniques that the contents are mucoidal in nature and demonstrate certain of the general properties of that mucoid.

Mucoid glands in developing cercariae.—Several investigators (Sewell 1922, Dubois 1929) have discussed variable groups of large glands, other than the penetration ("salivary") glands, in several species of virgulate cercariae. Sewell (1922) described only one pair of such glands in *C. indicae* LX and three pairs in *C. indicae* XLIII terming them "ventral salivary glands," but he did not describe them in other closely related cercariae. He considered that the glands were lost during a pre-emergence metamorphosis of cercariae and were thus truly larval structures. Dubois (1929, Pl. XIII, figs. 83-86) pictured apparent homologues of Sewell's (1922) "ventral salivary glands," but called them "les cellules ventrales" in contrast to the "cellules glandulaires de penetration." He described four pairs of such glands in *C. helvetica* IX but did not describe homologues for the closely related *C. helvetica* VIII or *C. helvetica* X.

In the present study of unidentified species of virgulate cercariae, three pairs of penetration glands also appear uniformly in all of these species, and homologous "ventral" glands have been determined to be relatively constant

in number and position in the bodies of all species. The ventral glands do not distinguish virgulate cercariae from non-virgulate species, however, because homologues occur identically in numerous groups of non-virgulate cercariae (Kruidenier, 1947). Variation in these glands in the species of cercariae here studied is in the time of their formation and development, and in their final size.

That the product of these glands is identical with contents of the virgulae was demonstrated by their identical reactions to the numerous stain techniques employed. Nearly mature, virgulate specimens are always present in preparations of developing cercariae, facilitating this comparison. The secretion of the glands was thus readily demonstrated to be mucoid in nature.

The mucoid glands develop close to the ventral surface just beneath the cuticula (Fig. 15) and extend into cercarial tissues in proportion to their final accumulation of secretion. The glands are located anterior, lateral, and posterior to the acetabulum and are closely associated with the penetration glands during the differentiation of the latter.

Until "mucus" begins to form, the mucoid glands of immature cercariae cannot be identified metachromatically and this occurs much earlier in some of the species than in others. Very young, premucoid specimens, heavily stained in thionin after corrosive sublimate fixation, frequently contain numerous, darkly staining, peripheral cells. Some of these cells seem to disappear, but the arrangement of the most prominent agrees with that of the cells which actively secrete mucoid substances in subsequent stages of development. It is possible that these darkly staining cells include the precursors of definitive mucoid glands. No processes can be traced from the presumptive premucoid cells, but their small size and proximity to the surfaces of embryos would render their delicate and necessarily short ducts practically invisible.

Concurrently with the formation of tissues and organs in differentiating embryos, mucoid cells shift or migrate to their definitive position. This involves little activity on the part of the cells themselves and the course of the ducts of mature glands is evidence of their progressive change in relative position. The sub-terminal oral sucker differentiates close to the anterior surface, displacing premucoid glands posteriad. Their ducts elongate as necessary while the pores retain their original position, or are carried variably into the buccal cavity by its invagination. The most anterior glands are at first confined to the wedge-like isthmus of parenchyma posterior to the mouth and between the oral sucker and the cuticula. Enlargement due to secretory activity forces these glands posteriad, beyond the limits of the oral sucker. Elongation of the mid-body region aids in this movement.

Identical factors influence the changes in position of the second and third pairs of glands, but in addition, the enlargement of more anteriorly located glands accentuates the changes in position of the posterior units by crowding them more severely. Others develop posterior to the acetabulum and appear to move slightly anteriad during cercarial development. This movement is relative and may be attributed to the differential elongation of cercarial

bodies posterior to the ventral sucker. In at least one of the species, the entire complement of glands is actively secreting before acetabular differentiation is evident and acetabular growth is a definite factor in changing the relative positions of gland complexes.

Mucoid substances at first form fine, uniformly dispersed droplets within the cells; but as secretion continues, individual droplets enlarge and then coalesce to form a deeply metachromatic mass which distends the cells, effectively masking the centers of mucoid formation. The final volume of individual glands varies with the species. In species possessing large virgulae the most anterior, paired glands become voluminous (Figs. 9-11) while species characterized by smaller virgulae develop noticeably smaller anterior glands (Figs. 13-15).

The anterior group of glands varies with the species, and consists of three or four pairs that tend to fill the ventral surface of the cercariae from acetabulum to oral sucker (Figs. 11, 15). Ducts from the most anterior pair pass ventrally and somewhat laterally between the oral sucker and the cuticula to open at the dorso-lateral margin of the mouth. Their terminal portions are carried slightly into the sucker by the inward development of the buccal cavity (Figs. 28, 29). Ducts from the second pair of glands run parallel and mesial to those of the first pair and can be followed to the ventral lip of the buccal cavity in some species, and just inside the floor of that cavity in others. A third pair of glands can be traced only to the ventral surface of the cercariae, immediately posterior to the oral sucker, where they appear to terminate. The fourth pair of glands, located in some species lateral to the acetabulum appears to discharge on the ventral surface, anterior and lateral to the acetabulum. The two or three pairs of glands posterior to the acetabulum empty through pores aligned and rather evenly spaced in the lateral ventral fields. These glands normally are very large and completely fill the posterior ventral region of the cercariae. The last pair empties, one on either side, at the postero-ventral margins of the cercariae, close to the base of the tail.

Formation of the virgula.—Confirmation of Sewell's statement (1922) that the virgula does not appear until late in the development of cercariae was obtained by a study of cercariae dissected from snails, supplemented by serial sections of cercariae fixed *in situ* in snail tissues. In all species, virgulae appear suddenly in nearly mature cercariae, before the latter have emerged from rediae. As observed by Sewell (1922), formation is not by a slow accumulation of secretion. Although the techniques employed differentiate even minute amounts of mucoid secretions, no mucoid formation occurs in the oral sucker at any time during cercarial development. Thus virgulae are not produced by elements within the oral suckers during cercarial development. This supplements the observation that no elements within the sucker actively produce virgula secretions in emerged cercariae.

The first two pairs of glands only can be associated with virgula formation in any of the species studied here. Usually only the first pair is involved,

resulting in the bipartite virgula, commonly reported by other investigators and most commonly found in the present study. Participation of the second pair of glands in virgula formation produces the quadripartite virgula of some species described earlier. Occasional individuals of species having simple bipartite virgulae in the normal emerged cercariae may possess more complex virgulae for a short period following emergence. The extra, smaller elements disappear very rapidly in such individuals. In any case, the product of pre-virgula glands is retained within their ducts, in the subcuticula of the oral sucker, thus forming the virgula organ. Sewell's report (1922, Pl. XXII, fig. 2) indicates this complexity in virgulae. His description (p. 208) is not complete enough to permit such an interpretation definitely, but *C. indicae* LX appears to possess a complex, four-part virgula.

The swollen ducts, which surround the buccal cavity so closely and form the virgulae, vary from species to species with the amount of secretion produced by pre-virgula glands, the secretion retained within the terminal ducts of those glands, and the developmental history of the ducts. In all cases the mucoid-filled ducts outline the buccal cavity without entirely occluding it, but in species with lesser amounts of contained secretion the final form of their virgulae more closely retains the pattern of pre-virgula ducts.

The final line of buccal invagination appears to be somewhat crescentic, with the points of the crescent directed posteriad. Ducts of the pre-virgula glands are carried into the forming oral sucker-buccal cavity complex by the buccal invagination. Ducts which cross the wings of the buccal crescent nearer the center of inward growth are carried further into the forming cavity than those ducts which are located more laterally. The final curvatures, apparently dependent on this factor, are greater in the case of the former ducts.

In some species the pores of the ducts move a very short distance into the cavity and locate near the lip of the mouth. In other species the apparent migration of these pores is more extensive and they finally locate in the depths of the buccal cavity. This seems to be dependent upon the early relation of such pores to the center of mouth invagination, those more centrally located migrating more deeply; but this is difficult to determine with certainty. The mature virgulae, thus dependent on the location of pre-virgula ducts and the amount of secretion produced in pre-virgula glands, may finally extend along the buccal cavity to the base of the oral sucker, almost to the poorly developed pharynx. Cover-glass pressure occasionally forces an enlargement of the virgulae in this direction, beyond the posterior limits of the oral sucker, into the pharyngeal cavity.

A mechanism whereby the secretions of unicellular glands in the bodies of cercariae are forced into their oral suckers is difficult to determine. Whatever they may be, the forces are of sufficient strength to empty completely and almost simultaneously the glands of most species, and to distend the oral sucker forcibly. The tissues of the oral sucker are strongly compressed and the buccal cavity is almost occluded by such forces. The failure of

Sewell (1922) or Dubois (1929) to associate the virgulae with these glands is due to the rapid discharge of the glands and the transitory nature of an observable connection. Careful examination of numerous dissected specimens and sectioned preparations discloses only a very few specimens in which ducts are only partly filled (Figs. 28, 29, 32). Secretions must follow the ducts of the glands through the restricted isthmus of tissue between the oral sucker and the ventro-lateral cuticula.

In numerous pre-virgula specimens, dissected from rediae, irregular masses of secretion distend the ducts of the anterior glands. The most distal of these masses usually lie close to the oral sucker and testify to the very real barrier to discharge there. In many instances, masses of secretion in the parenchyma immediately below the lip of the buccal cavity, indicate that the lumina of ducts curving into that cavity are closed by the pressure of the oral sucker against the cuticulala at the lip of the buccal cavity. These irregularities are not as pronounced in specimens *in situ*, sectioned serially, and must therefore be much less common in normally developing cercariae.

The premature, partial discharge of mucoid glands seems to be stimulated by the physiological saline solutions in which the specimens are dissected and examined. Hypertonicity of media causes this reaction through pressures on the glands caused by the dehydration and consequent shrinkage of the bodies of cercariae. In many of the preparations studied, such shrinkage had occurred. Swelling of the cercariae produces identical effects on the glands. The latter occurs in hypotonic media which induce an influx of fluid into the bodies of cercariae. These observations indicate that increased pressures within the cercariae cause glandular discharge.

Natural factors intrinsic to maturing cercariae may stimulate parallel conditions and cause similar activity of the glands. Cercarial growth is correlated with tissue differentiation and accompanied by a normal increase in the non-mitotic functional activity on the part of the maturing tissues. This is evidenced by a progressive dilution of the general orthochromatic-blue chromophilic reaction to thionin and toluidine blue of developing cercariae and is best exemplified by the greatly increased accumulations of secretions in the penetration glands. It is probable that increased turgidity of the cercariae would accompany such activity. The progressive formation and hardening of the cuticula increases the elasticity of the surface layer of the cercariae and this must transform inward greater proportions of such pressures as those due to cell growth. It simultaneously erects barriers to the free exchange of fluids between cercariae and their environment. This combination of growth changes results in the heightened intra-cercarial pressure evidenced by the readily observable, closer association of cells in matured cercariae in general. It correlates with and is probably the cause of the discharge of the finally enlarged mucoid glands whose turgor also reaches a maximum at this time and assists them in exceeding their discharge threshold.

If these factors, as discussed above, are active in the formation of the virgulae, the question arises as to why virgulae form before the discharge of

other similar mucoid glands in the cercariae, whose ducts follow a comparatively direct path to the surface of the body. The pores of all of the glands are small thus restricting discharge through them. The substances from pre-virgula glands encounter less resistance, as they fill the space of the mouth and compress oral sucker tissues, than is offered by the minute pores of the glands. Similarly, the elasticity of the buccal cuticula permits the enlargement of virgulae into the mouth cavity by offering less resistance than the pores of the virgulae to the flood of material.

As the virgula forms by influx of mucoid material, thus creating definite pressures in that organ, the oral sucker markedly lengthens. The portion of the oral sucker anterior to the mouth cavity shows little or no change, but that portion posterior to the mouth enlarges considerably (Figs. 35, 36). The compression of the tissues within the sucker has already been commented on. Tissues adjacent to the enlarged portion of the sucker show no signs of compression, demonstrating the compensatory shifting which occurs in these contiguous tissues. The evacuation of the contents of the large pre-virgula glands provides ample space in the bodies of cercariae for this rearrangement of cercarial tissues posterior to the oral sucker. The tissues within the sucker are prevented from similar rearrangements by the confining resistance of the limiting membranes of the sucker, hence their flattened state. The capability of the sucker to enlarge renders possible the formation of the virgulae. The counter tension, which must be maintained by the elastic limiting membrane and tissues under constant distorting pressure, provides a mechanism for the constant, if slow, discharge of the contents of the virgulae during the lives of emerged cercariae. The relatively poor development of suckers as here reported may be attributed to the presence of the virgulae in these cercariae.

Function of the virgula.—To determine the function of the virgulae many cercariae were studied under various conditions. Care was necessary in order not to confuse the product of the penetration glands with that of the virgula. The normal, unrestricted creeping activities of different species of virgulate cercariae vary in strength; but in all species these movements seemed stronger than warranted by the limited oral musculature. It was noted that swimming or resting cercariae paused periodically to bend double, bringing their acetabula into contact with their mouths. Occasionally cercariae were observed to be attached strongly to the bottom of containers or to debris by means of their oral suckers only. Such attachments were surprisingly strong in view of the lack of oral musculature revealed by histological studies.

Cercariae allowed to remain in their containers after emergence from the snail became attached to bits of debris by fine strands of an almost invisible, clear material. When a fine needle was passed gently between the cercariae and the debris, the cercariae were led about by the needle. Occasionally, passing the needle near the mouths of free-swimming cercariae similarly caused the cercariae to follow the needle. This movement could not be accounted for by water currents established in the immediate vicinity of the cercariae by passage of the needle. In species which were most readily led,

almost all of the individuals showed coarse strands of material emerging from their mouth cavities. In species which less readily followed the needle, such strands were more rare.

The needle-following movement was induced in cercariae freshly emerged from the snail as well as those that had been in water for some time. In some instances, deliberate contamination of cercariae with snail mucus could easily be detected. Cercariae in such cases were readily led, but their connection to needles was coarsely visible and their orientation as they were dragged through the water was extremely variable. It was thus assumed that the attachment of cercariae to debris and their transferred attachment to needles was by means of an adhesive secretion of cercarial origin.

This assumption was strengthened by testing species of cercariae which do not produce secretions similar to those contained by the virgula. Such cercariae never followed the needle closely, as do virgulate species. The advantage to virgulate cercariae of such attachment to the substrates of their normal habitat of flowing water is as obvious as is the aid which this adhesive substance would furnish in maintaining the cercariae on their next host.

These views of the function of the virgula are supported by observations of microscopic strands of secretion, seen issuing from the mouths of living specimens placed in dilute physiological saline-azure I solution, which became swollen on contact with the surrounding medium, fused into one strand almost immediately after emergence from the secretory pores, became attached to the sub-stratum and, as the cercariae moved about under the cover glass, left a track by which the paths of the cercariae could be followed. As the secretion is given off, the virgulae gradually decrease in size. The secretions of the penetration glands tend to retain their identity as small rounded granular globules and are readily differentiated from the secretions of the virgula. Whole mount preparations demonstrate that strands of material emerging from the mouths of cercariae arise deep inside the buccal cavity and extend for some distance externally (Fig. 2).

Use of the virgulate contents by the acetabulum is implied by periodic contacts between sucker and acetabulum in which the latter is furnished with the adhesive substance from the virgula. Collections of this secretion in the fairly deep pit of the acetabulum are easily demonstrated on numerous permanent whole mount preparations. The acetabulum of virgulate cercariae is, however, strongly muscular and in no apparent need of this substance and, as shown later, some of the adhesive materials on the acetabulum may be a remnant carried from pre-emergence stages by the cercariae.

Studies employing neutral red and Nile blue sulfate showed that the contents of the virgulae became roughly granular and decreased in quantity as passage of time permitted the surrounding medium to evaporate. Shortly before cercariae become immobilized by pressure their movements increase markedly. It is believed that this increased movement together with a greater use of virgula secretion, and perhaps greater cover-glass pressure on the virgulae, causes the loss of virgula contents. In cercariae protected from cover-

glass pressure by the periodic addition of water to the aqueous mounts, a corresponding loss of virgula contents occurred. The "inchworm" creeping motions of such cercariae were stronger than these same movements in unconfined specimens, and activity of the cercariae is thus correlated with decrease of virgula contents, substantiation that general body activity aids in the flow of virgulate secretion.

In vessels containing all ages of adult cercariae from freshly emerged to dead specimens, some individuals had lost their virgulae completely. Other virgulae showed varying degrees of depletion, to complete evacuation. All freshly emerged cercariae, however, possessed a virgula. These observations confirm the conviction that cercariae definitely utilize virgula material during their active free-living existence. Certain artificial stimuli, such as cover-glass pressure or dilute salt solutions, increase the normal emission of virgula secretions, but are not necessary corollaries to such demonstrations. When members of a species of *Ephemerida* were exposed to one species of cercariae, it was noted that, in spite of the vigorous efforts of the ephemerids to dislodge them and the apparent weakness of the cercariae's oral suckers, the cercariae were able to maintain themselves on any part of the insects' bodies. This doubtless is made possible by the use of an adhesive substance, the secretion of the virgulae.

Sewell (1922), Yamaguti (1938), and others have expressed the opinion that this organ is used during penetration into intermediate hosts. Persistence of virgulae during the free life of the carcariae and the fact that virgula discharge is accelerated by placing cercariae in physiological saline, indirectly confirm the belief that the virgula continues to function actively subsequent to the free life of the parasites. Virgula discharge is probably hastened during migration of cercariae through host tissues; but experimental infections attempted in the present investigation were unsuccessful, making direct observations of this interesting phase impossible. The presence of a superficial coat of material over the surface of emerged cercariae which, so far as can be determined, is identical with the substance within virgulae, makes it improbable that such studies can be made. This coating will be discussed below.

Actual penetration of laboratory hosts by virgulate cercariae has thus far not been observed. In a study of *Loxogenes liberum*, Yamaguti (1937) found that the virgula disappeared shortly after the penetration of cercariae, a direct indication of its use during penetration. Seitner (1945), however, found that "the organ persists beyond penetration and even encystment and can be seen in young metacercariae"; but in his specimens the virgula organ disappeared during metacercarial development after encystment had occurred.

In a survey of numerous species of insects, preliminary to attempted infection of intermediate hosts, it was found that these hosts contain widespread infections by metacercariae in all stages of development. Stylets, discarded by older metacercariae but still retained by young parasites, were tentatively used to identify such metacercariae. It seemed certain from such studies that some of these metacercariae were derived from virgulate cercariae; but no virgulae

were found in any of the metacercariae examined, regardless of their apparent immaturity. This confirms Yamaguti's (1937) report, but it does not necessarily contradict Seitner's (1945).

It seems probable that the eventual disappearance of entire virgulae may depend on their size, the length of the migratory route taken by the cercariae, and the correlated rapidity of encystment after entrance into the host. That such factors are important is indicated in one of the species of cercariae studied in which cyst formation was commonly initiated when cercariae were stimulated by cover-glass pressure. Their tails were actively detached and delicate cyst walls appeared to form normally. Such encysted parasites retained their virgulae after apparent complete encystment. Their penetration glands also seemed normal and unused, but in numerous species these glands reportedly persist for variable periods after encystment, despite their undisputed use during penetration, and they disappear during subsequent metacercarial development. These data suggest that the contents of virgulae are also used during penetration into the second intermediate host. A final determination of this must await further experimentation.

The discharge of virgula substances ensures that penetrating cercariae become closely surrounded by masses of this secretion as they move forward in host tissues. Such masses would reinforce a similar, existing coat, retained through their free life, and derived from other special glands in developing cercariae (*v. infra*). This layer may provide a constant lubrication, valuable in easing cercarial movements through host tissues and possibly minimizing injury to those tissues. It also provides a viscous layer about the cercariae for protection against antagonistic fluids of the host or tissue reactions. Thus the immunity of cercariae is supplemented until they can adapt themselves more completely to their new environment. The mucoid envelope might also protect cercariae from an excess of the secretions of their own penetration glands, through which they must also migrate. Mucoids (Meyer, 1945) frequently show high resistance to enzymic digestive activity.

Thus the virgula secretion is admirably adapted to provide mechanical and physiological aid and protection to migrating cercariae. That such functions are essential to these cercariae cannot be conveniently demonstrated at present. Many kinds of cercariae use secretions of penetration glands without having virgula secretions for protection and without the aid of other mucoid glands. This indicates the wide variety of adaptive mechanisms that may be encountered in the trematodes, but it does not negate the value of such secretions to virgulate species.

Function of non-virgulate mucoid glands.—In most species all the mucoid glands empty before the cercariae emerge from rediae; but in one species four small metachromatic masses of secretion, remaining from the incomplete discharge of the two most anterior pairs of mucoid glands, are retained by emerged cercariae. These remnants show no indication of cellular organization; they are paired and located just behind the posterior border of the oral sucker. Sewell (1922) observed similar masses in *C. indicae* XLIV. In his illustration (Pl. XX, fig. 6) these structures do not resemble a pharynx,

Sewell's interpretation, in any respect, but closely resemble droplets of virgula-like substance, which I interpret them to be. While all the mucoid glands empty at approximately the same time, pre-virgula glands evacuate slightly before the others.

All the mucoid glands, not engaged in the formation of the virgula, discharge into the space between the cercaria and its embryonic membrane. Their secretion is at first scattered irregularly over the surface of the cercaria. Ordinarily the largest aggregations of this material are found on the ventral surface, nearest the pores of discharge, but numerous smaller droplets scattered over the general surface of the cercaria indicate the viscous adhesive nature of the secretion. The substance is distributed by movements of the cercaria still within its embryonic membranes, until a complete, homogeneous envelope, adherent to the cuticula (Figs. 28-43) is formed. It could not be determined whether any of this secretion contributed to final cuticula formation; but it is not visible around the tail of any of the specimens and obviously is not essential to the cuticula of that organ. The very close adherence of the mucoid substance to the cercariae is evidenced by its lack of concentration in the vicinity of rediae studied *in situ* in sections. Its slow dispersal is indicated by the diminished amount present around mature emerged cercariae.

In addition to the large mucoid glands described above, two distinct types of smaller, unicellular, metachromatic glands can be seen in many of the serial sections and whole mounts that were treated with thionin or toluidine blue. These two series of glands differ from one another in size, distribution and their degree of metachromasy.

The smaller of these glands are numerous and are distributed over the entire surfaces of the cercariae. Their lessened reaction to the metachromatic dyes indicates that their secretion is not the same as that of the large mucoid glands described along the ventrum of the cercaria. They may form a portion of the cystogenous gland complex, but this cannot be determined at present.

The second type of gland is highly metachromatic, resembling the large ventral glands and the contents of the virgula in this respect. They are limited to the dorsum of the cercaria in the several species in which they have been observed (Figs. 28, 29). They seem to disappear by the time the large, ventral mucoid glands have discharged, but they were observed only in the cercariae sectioned *in situ* in the snail tissues and few data are available concerning their history. It appears probable that, functionally, they may supplement the extra-virgula, ventral, mucoid glands.

The actual function of the mucoid envelope surrounding the cercaria cannot be determined experimentally. It may aid the cercaria in its migration within the snail hosts by providing lubricating material, but analysis of the changing environment to which cercariae are subjected suggests further possibilities.

Migrant, mature cercariae, emergent from their rediae must either be

physiologically adapted to the next phase, or host, in their life histories or they must soon undergo the changes that result in such an adaptation. Cessation of development after the attainment of a definite stage of development is obvious in all of the virgulate species studied. Obviously they are unable to develop further in the snail, although the cercariae, *sensu strictu*, are not individuals in a life history cycle. Rather, through the further development of which they are capable, cercariae are immature adults. It is not known how long virgulate cercariae remain in the snail following their escape from rediae but the final changes in the maturation of these cercariae thus render them unsuited to the snail as a host although they remain subject to its influences.

At the approximate time of mucoid gland discharge a reduced orthochromatic-blue chromophilia to toluidine blue and thionin can be readily observed in the sectioned, *in situ*, specimens although this change is masked in whole mounts by the presence of the mucoid envelope at their surface. This is an indication of the final physiological changes that must occur at this time in the tissues of the cercariae. The interpolation of another layer, the mucoid envelope, between the cercariae and snail tissues cannot fail to further protect them from the predictable effects of physiological imbalance during their migration through snail tissues.

The retention of a thin film of mucoid by emerged cercariae may be indicative of its value in combating harmful environmental factors. Such a film may, for example, decrease the influx of water into the cercariae. That such an influx occurs, and is obviously deleterious, has already been discussed. Mucoids commonly absorb water, but the amount that cercarial tissues would absorb from that passed by a saturated mucoid protective coating must be lower than would be absorbed were its cuticula in direct contact with the aquatic environment. Other unknown factors may also favor the retention of a film of mucoid by cercariae.

Summary.—The virgula has been studied anatomically, chemically, and histochemically during its entire history in several species of cercariae. The study of this structure during the process of penetration is still incomplete, but my observations are not contradicted by the investigations of others.

In late developing and emerged cercariae, virgulae are primarily paired structures, in some species secondarily fused, the reservoirs for secretions from paired unicellular glands arising in the body posterior to the oral sucker. Paired pre-virgula glands empty through individual ducts into a forcibly enlarged oral sucker to form virgulae. The contents of virgulae are readily hydrolized by inorganic acids or weak bases; a precipitate caused by acetic acid is hydrolizable by inorganic acids, reactions that are indicative, but not proof, of the presence of mucoid compounds. Special mucoid stain techniques confirm the presence of mucins in virgulae, pre-virgula glands, and homologous glands in the cercariae. Observations of emerged living and permanently mounted specimens indicate that mucin discharged from the virgulae supplements the weak oral sucker as a means of attachment. Further data,

partly inferential, indicate that mucins from virgulae, and the mucins of non-virgulate glands, serve to lubricate the cercariae during pre- and post-emergent migrations in intermediate hosts, and to immunize parasites to the anti-parasite activities of the hosts.

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EXPLANATION OF PLATES

All drawings (Figs. 1-27) were made with the aid of a camera lucida from permanent preparations with the exception of Fig. 4, Pl. I, which was drawn free-hand. One unit of the scales indicating magnification equals 0.01 mm., with the exception of Fig. 4, Pl. I, in which the value is 0.015 mm. All photomicrographs (Figs. 28-43) are contact prints of negatives produced by the enlargement of positive color transparencies; their indicated magnification is approximate. Figs. 1-3, 5-11, 28-36 relate to one species of virgulate cercariae, Fig. 12 to another, Figs. 13-18, 41-43 another, Figs. 19-28, 37 another, and Figs. 38-40 another species. Fixation and stains employed are indicated.

ABBREVIATIONS

b.—buccal cavity
c.—cuticula
d.—duct
dm.—dorsal mucoid gland
m.—mucoid
mo.—mouth
os.—oral sucker
pg.—penetration gland
ph.—pharynx
rf.—reproductive fundament
sc.—subcuticular metachromatic cell
st.—stylet
v.—virgula

PLATE I

Figs. 1-3, 5-8, 12 are drawn to same scale and Figs. 9-11 are drawn to the same scale.

Figs. 1-12.—1. Virgula from an emerged cercaria, ventral view. Acetocarmine, glycerine. 2. Virgula from a living, emerged cercaria, lateral view, showing strands of mucoid being discharged through the mouth. 3. Virgula from a mature, non-emerged cercaria, ventral view. Mercury bichloride, thionin. Whole mount. 4. Composite, free-hand drawing of living, emerged cercaria illustrating the general features of virgulate species. 5-8. Consecutive frontal sections through the anterior end of a non-emerged cercaria showing the relation of the virgula to other structures of the anterior end. Note the absence of muscles in the oral sucker. Bouin, thionin. 9-11. Developmental stages of virgulate cercariae. Whole mounts, mercury bichloride, thionin. 12. Virgula from an emerged cercaria, lateral view. Acetocarmine, glycerine.

PLATE II

Figs. 13-24 are drawn to the same scale as are Figs. 25-28.

Figs. 13-28.—13-15. Developmental stages of virgulate cercariae. Whole mounts, mercury bichloride, thionin. 16. Anterior portion of a mature, non-emerged cercaria showing virgula and mucoid granules within ducts from the penetration glands. Mercury bichloride, thionin. 17. Virgula from an emerged cercaria, ventral view. Aceto-carmine, glycerine. 18. Virgula from an emerged cercaria, ventral view. Aceto-carmine, glycerine. 19. Virgula from a mature, non-emerged cercaria, lateral view. Mercury bichloride, thionin. 20-23. Virgulae from emerged cercariae showing stages of depletion (see Fig. 19). Aceto-carmine, glycerine. 25-27. Consecutive frontal sections through the anterior end of a non-emerged cercaria showing the relation of the virgula to other structures of the anterior end. Bouin, thionin. 28. Cross section through the oral sucker of a pre-emergent cercaria to show the relations of the virgula to the buccal cavity and oral sucker. Bouin, thionin.

PLATE III

Figs. 28-32.—28-29. Consecutive sagittal sections of a non-emerged virgulate cercaria. Note the manner in which the duct from the mucoid gland follows the edge of the buccal cavity, the small dorsal mucoid glands, the closely associated penetration glands, and the absence of a peripheral mucoid sheath. Bouin, thionin, ×950. 30. Frontal section through non-emerged virgulate cercaria showing the relation of the virgula and the buccal cavity. 31. Cross section through the oral sucker of a non-emerged virgulate cercaria. Bouin, thionin ×440. 32. Sagittal section through non-emerged virgulate cercaria showing a virgula in formation. Note the peripheral mucoid sheath, the swollen duct from an anterior gland and the enlarged oral sucker. Compare with Figs. 28, 29. Bouin, thionin, ×440.

PLATE IV

All figures are of whole mounts. All specimens were fixed in mercury bichloride and stained in thionin except those in Figs. 34, 41. The specimen for Fig. 34 was prepared by the Ripart and Petit methyl green technique, that for Fig. 41 is stained in mucicarmine.

Figs. 33-43.—33. Developing cercaria, lateral view, ×440. 34-35. Dorsal views of virgulae showing the size difference due to variation in the fixation techniques employed, ×440. 36. Emerged cercaria of virgulate species A, ventral view, ×440. 37-38. Emerged cercariae, ventral view, ×440. 39-40. Developing cercariae showing mucoid glands and ducts (Fig. 40), ×440. 41-43. Emerged cercariae of the same species. Fig. 42 is a lateral view; Figs. 41, 43 are ventral views. Note the partial depletion of the virgula of specimen B (Fig. 41) and the almost complete disappearance of the virgula in the specimen of Fig. 43 (×600), an indication of the longer free life of these individuals. ×440, exception noted.

PLATE I

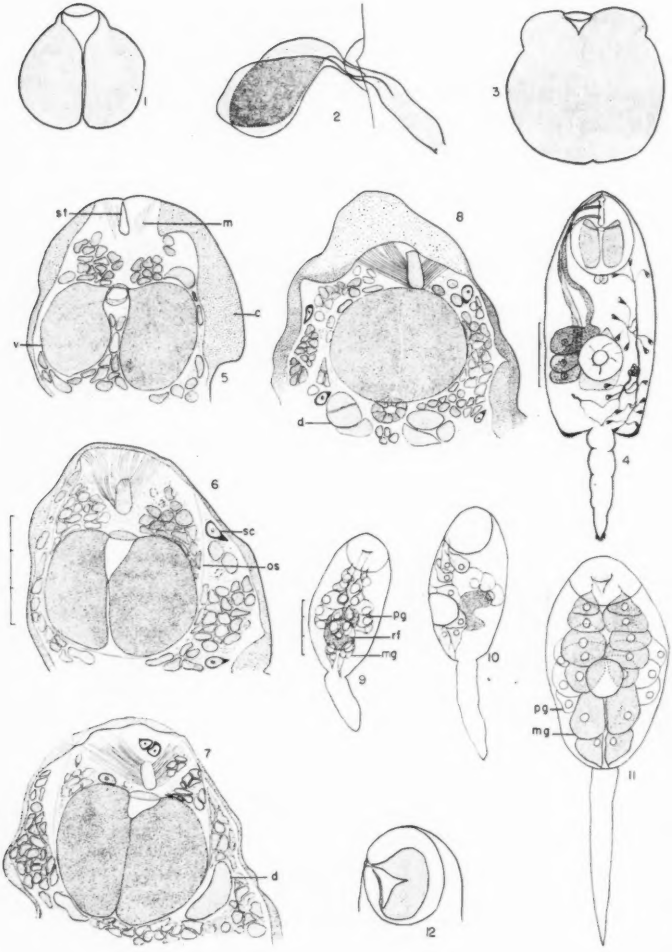

PLATE II

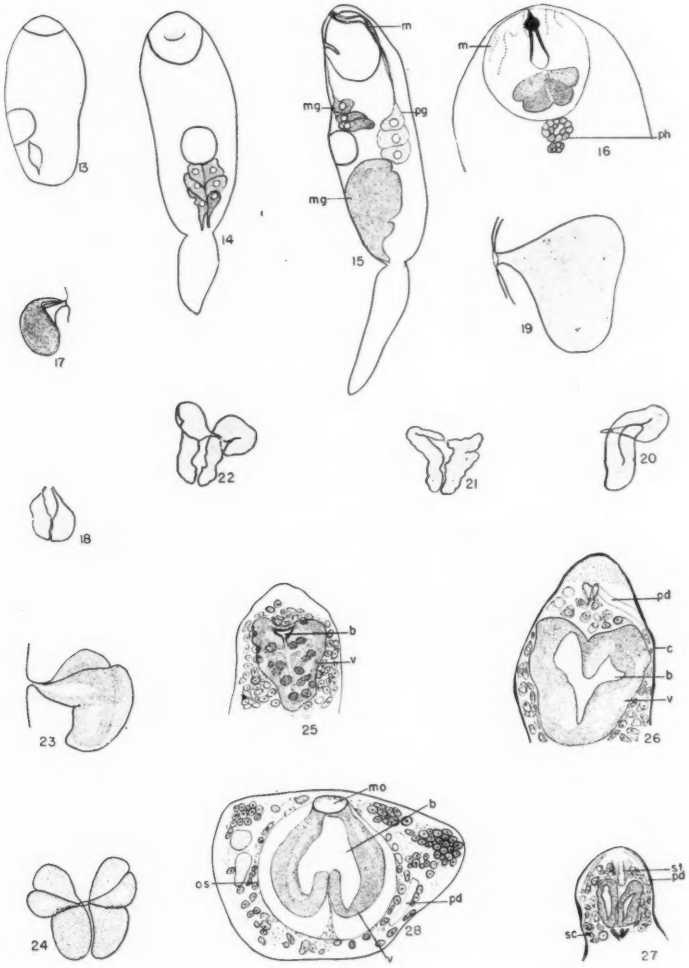
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PLATE III

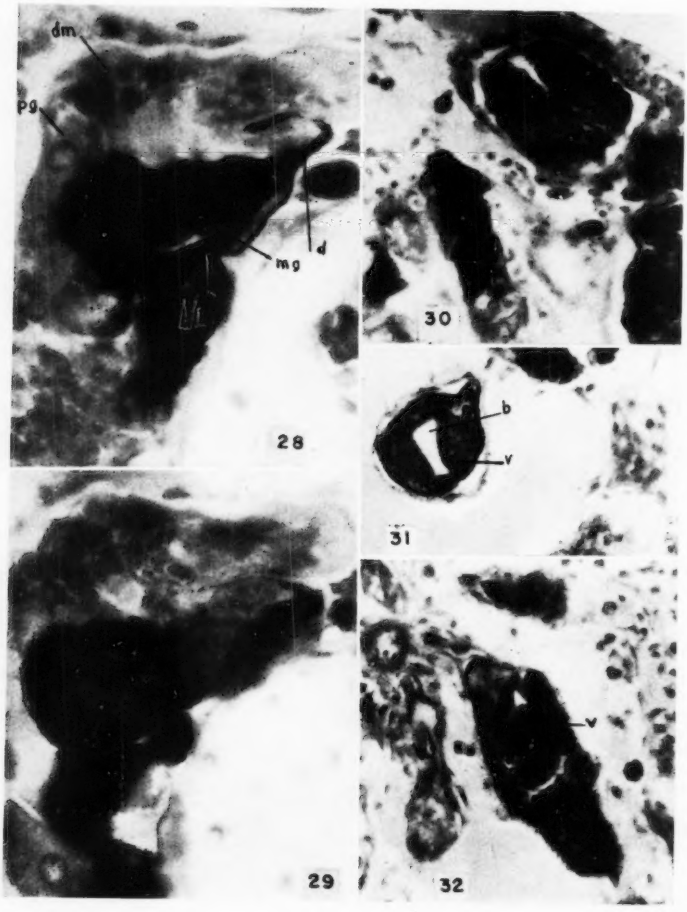
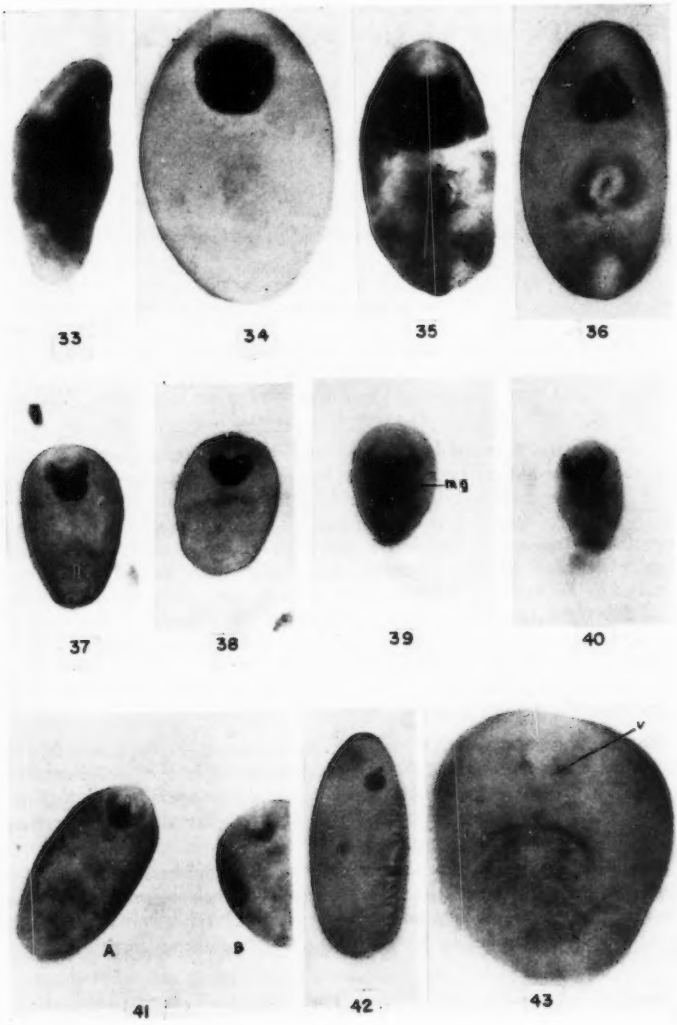


PLATE IV



The Structure and Classification of Four Plants From the New Albany Shale[1]

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Introduction

There are four genera heretofore reported from the black shales of the east central interior region of the United States which have been found elsewhere only in Devonian strata. These four genera are *Callixylon, Asteroxylon, Protolepidodendron* and *Reimannia.*

Callixylon was founded by Zalessky in 1911 on material from the upper Devonian of the Donetz Basin in south Russia. The genus, several species of which have been described, is known chiefly from American material. Specimens have been recorded from numerous horizons throughout the Upper Devonian. *Asteroxylon* was first reported by Kidston and Lang from the Rhynie Chert of Middle Devonian age and later a second species was described by Kräusel and Weyland from rocks of comparable age in the vicinity of Elberfeld, Germany. Little is known of the anatomy of the stem of *Protolepidodendron* Potonié and Bernard from the Lower and Middle Devonian, as the genus was founded essentially on compression material. *Reimannia* was instituted by Arnold in 1935 on a single species based upon a small collection from the Middle Devonian of New York state.

Recent stratigraphic studies have resulted in placing in the Lower Mississippian the upper portion of the New Albany Shale of Indiana and Kentucky, from which these four genera have been reported. It is desirable, therefore, to review the four genera mentioned above and to reevaluate their present assignment to established Devonian genera.

It will be seen below that the retention of three of these four species of plants within the assigned genera is untenable. Their removal necessitates new assignments, and as they are not congeneric with other known forms new genera have been created to house them. The fragmentary nature of some

[1] This is the twelfth paper in a series of joint paleobotanical contributions of which we are co-authors. The order of listing of names is not significant here or on any of the previous papers of the series as we are equally responsible for the research leading to the contents of each contribution and the preparation of the manuscripts.

and the limited material available of all makes this task an unsolicited necessity.

If ultimately we have the opportunity to study the remainder of the original material or if additional specimens are found from which critical preparations may be made, emended descriptions of these species may well allow a more conclusive consideration of their organic relationships and their systematic positions.

CALLIXYLON

Callixylon Newberryi (Dawson) Elkins and Wieland is a well-established species from the Devonian portion of the New Albany Shale (Upper Blackiston). In 1939 Read and Campbell included in their tables of species from the upper portion of the New Albany Shale, prinicpally the upper Sanderson (Falling Run) formation, a new species of *C. brownii* (pp. 437, 441), with no accompanying comment or description except the horizon and localities where it occurs (pp. 447-448). In a consideration of a number of pieces of secondary wood showing affinity to *Callixylon*, we investigated the slides labelled *C. brownii* in the collections of the U. S. National Museum. Without doubt this material formed the basis of the following report of *Pitys brownii* by Read (1936), p. 221). His entire description and discussion are as follows:

"1. Pith large, parenchymatous without medullary or circum-medullary strands.

"2. Primary xylem in discrete mesarch bundles at outer edge of pith, sometimes separated by a small amount of parenchyma from the secondary wood, sometimes in direct contact.

"3. Rays dilated at inner margin of wood, narrowing quickly to uni- or bi- or triseriate types.

"4. Secondary wood cordaitalean.

"5. Leaf trace anatomy not known.

"This form is best referred to the genus *Pitys* in view of the structure of its primary wood, despite the absence of medullary and circum-medullary strands."

This preliminary description furnishes insufficient evidence for assignment of the material to *Pitys* or its transfer to *Callixylon*, to which it was referred without comment by Read in Read and Campbell (1939).

The characteristics emphasized in the recognition of *Callixylon* are, first; the presence of discrete mesarch primary vascular strands either in direct contact with or separated by a very few parenchymatous cells from the secondary wood, vascular elements being absent from the pith or occasionally present as isolated tracheids and, second; by the radial alignment of discontinuous pit groups as seen on the radial walls of the secondary wood tracheids (fig. 7).

In the absence of preserved pith and primary wood, several species have been referred to the genus *Callixylon* on the characters of the secondary wood alone, based essentially on the occurrence of the radial alignment of pit groups. The assumption in these instances is that the occurrence of the radial alignment of pit groups is adequate evidence for the recognition of the genus

Callixylon as no other examples of this phenomenon are known to occur in plants living or fossil (Arnold 1947, p. 283).

In the instance of *C. brownii*, while the transverse sections of the stem show well the nature of the pith, primary and secondary wood, the nature of the pitting of the secondary wood cannot be determined with certainty from longitudinal sections due to the nature of the preservation. We have been able to find no portion of the original specimens from which we might have been able to determine this character by means of reflected light, a method which has been successfully used in the examination of our own material. It is therefore necessary to give the anatomical features of this species which are determinable from the slides available.

Transverse Sections.—The tissues preserved in the slides seen are the pith, the primary wood and a cylinder of secondary wood (fig. 1). Additional layers of secondary wood, if ever present, and the cortex have been lost. The pith is relatively large and cylindrical, averaging 15 mm., in diameter, and consists of essentially uniform parenchymatous tissue. The width of these parenchyma cells, as seen in longitudinal section, frequently exceeds the height. This is especially true toward the periphery, where the width may be one and one-half to two times the height. No specialized cells of any sort have been observed, although differences in mineralization may give a false impression of the nature of certain cells.

The most complete specimen available is shown in figure 1. Here it appears that about one-sixth of the woody cylinder has been lost. At the margin of the pith in this section are 19 discrete primary vascular bundles, in some instances in direct contact with the secondary wood and in others separated from it by one or two parenchymatous cells. Probably about 24 bundles were present in the complete cylinder. The bundles are mesarch (fig. 5) and while there is considerable variation in the position of the protoxylem, in some approaching the inner margin of the bundle, in others the outer margin, in the majority the protoxylem is centrally situated. The bundles vary in outline; in some it is the radial diameter which is the longer and in others the tangential.

The inner part of the secondary wood is indistinctly divided into segments opposite each of the primary vascular bundles. This condition is not particularly conspicuous and many of the rows of tracheids abut directly against the pith. These segments are only slightly demarcated by the dilation of the rays between the primary bundles (figs. 1, 5) which narrow rather abruptly from the edge of the pith.

In transverse section the tracheids of the secondary wood are square to rectangular in outline, giving the effect of uniformity and regularity, although there may be marked variation in size between adjacent rows. The cells of adjacent rows of tracheids may vary from 20 to 60 microns in diameter. The average radial diameter of the tracheids is about 42 microns whereas the tangential diameter is about 36. Occasionally the tangential diameter is greater

than the radial. The rays are narrow and uniform throughout their length except at the inner end of certain rays which abut directly against the pith. In these the ray may be somewhat wider for a short distance (figs. 3, 5).

Tangential Sections.—The rays are narrow and relatively low (fig. 8). Approximately 50 per cent of all rays are 6 cells or less in height. About 75 per cent are 9 cells or less and approximately 90 per cent are 15 cells or less, the highest observed being 25 cells. The great majority (80 per cent) are uniseriate. The remainder are locally biseriate for one or two cells. No rays are biseriate for their entire height and none was observed to be more than two cells in width. The tangential diameter of the ray cells varies from 20 to 35 microns, with an average diameter of 27.

Radial Sections.—The cells of the rays average slightly more than 25 microns in height, and from 68 to 113 microns in length, averaging about 97 microns. The end walls are vertical to inclined and the cells present a uniform brick-like organization. No ray tracheids were observed. It is a disappointing feature of these slides that pitting on the radial walls of the tracheids cannot generally be observed. This condition, due no doubt to the nature of the mineralization, is a feature in common with all of our collections of similar nature. Though the pitting is readily observable by reflected light on most fresh fracture surfaces it is generally lost or indistinguishable in thin sections. In one section only, Dc 2-4(2), were pits observed at all, and the determination of their distribution is far from conclusive, although the meager evidence presented suggests the distribution characteristic of *Callixylon*.

Longitudinal sections through the circum-medullary vascular bundles are generally poor. In one section, however, scalariform tracheids of the primary xylem are seen to be definitely separated from the secondary xylem by one or two parenchymatous cells. While the majority of the circum-medullary bundles possess a single mesarch protoxylem strand, occasionally a bundle possesses two quite distinct and regularly arranged strands (fig. 4). There is some evidence that this double bundle may be correlated with the development of the leaf trace itself. In figure 3, taken somewhat above figure 4, one may see both the leaf trace at the beginning of its passage through the secondary wood, and the reparatory strand. The leaf trace presents an identical picture with the double protoxylem area of the circum-medullary strand seen in figure 4. The reparatory strand possesses the usual single, centrally situated protoxylem. At a level well above that of figure 3 the leaf trace has passed outward through the secondary wood, and the reparatory or remaining circum-medullary bundle possesses two protoxylem areas just as seen in the lower level shown in figure 4.

What cannot be determined is whether this double bundle is definitely related to the development of the leaf trace in all instances or whether it is a condition which occurs occasionally. Seward called attention to a "twin-bundle" of *Callixylon Triflieve* (Seward 1917, p. 291 and fig. 489 A and C) and suggested that it might indicate the leaf trace would be double. Neither can we determine from the material available the details of separation of the

leaf trace and reparatory strand (fig. 3). And finally we cannot determine when, if at all, the trace divides into two or more separate bundles during the course of its passage to the leaf.

Corroborative Material.—Before referring this stem to the genus *Callixylon* it is pertinent to consider some collateral information. Isolated pieces of secondary wood are common in all the collections of phosphatized wood from comparable horizons in Indiana and Kentucky. A number of these pieces which were split longitudinally along radial surfaces were studied under reflected light. Conspicuous radial alignment of discontinuous pit groups occurs in specimens from Crab Orchard, Kentucky (fig. 9); Junction City, Kentucky, which is the source of the material from which the slides described above were made; Kinderhook, Illinois (fig. 10); and New Albany, Indiana. These specimens differ among themselves in detail of pit groups, rays and size of tracheids; all differ from the best known American species of *Callixylon, C. Newberryi* (fig. 7), although some approach the observable characteristics of *C. brownii.*

Discussion.—If radial alignment of pit groups in the secondary wood is sufficient evidence to identify *Callixylon,* then *Callixylon* is a common fossil at these and other localities of the same horizon.

What disposition is to be made of the species originally named *Pitys brownii* by Read (1936) and later mentioned as *Callixylon brownii* (Read and Campbell, 1939)? The absence of tracheids from the pith and the proximity of the primary vascular bundles to the secondary wood, appear sufficient to remove this species from the genus *Pitys.* In view of its anatomy, no details of which differ essentially from the recognized characteristics of *Callixylon,* and in view of the corroborative evidence that *Callixylon* is a common fossil in this horizon, it appears desirable to transfer this species officially from *Pitys* to *Callixylon* and to emend and amplify the original description.

This conclusion, of course, might be altered if plant fossils other than *Callixylon* are found to possess radial alignment of pit groups, or if specimens of *Callixylon brownii* are found which show pit characteristics not compatible with those of the genus.

CALLIXYLON BROWNII (Read) Hoskins and Cross

1936. *Pitys brownii* Read. Jour of Paleont. 10 (3): 221, pl. 29, fig. 4, & 5.

Pith.—Circular in cross-section, relatively large, approximately 15 mm. diameter, cells parenchymatous, relatively uniform, broader than high, especially near the margins, average size in long. section about 130 μ in radial diameter and about 70 μ in height; no vascular elements within the pith except primary bundles at the margin.

Primary Wood.—A ring of discrete mesarch vascular bundles border the pith, about 24 in number in specimen considered, either in direct contact with or removed from the secondary xylem by one or two parenchyma cells; posi-

tion of protoxylem varies slightly, though it is centrally situated in the bundle in a majority of instances.

Secondary Wood.—Xylem: cells in cross section square to rectangular, giving appearance of compactness and uniformity, averaging 42 μ in radial diameter and 36 μ in tangential. The inner portion of wood weakly divided into inconspicuous segments opposite each primary bundle; pits on tracheids not generally observable.

Rays.—Uniseriate (80%), occasionally locally biseriate; low, (50%) 6 cells or less in height, 9 cells or less in height (75%), none over 25 cells in height seen; cells average 27 μ in tangential diameter, 97 μ in radial diameter (length) and 22 μ in height; and walls vertical to inclined; general appearance regular and brick-like; no ray tracheids observed.

Pits.—Bordered, crowded, 3-4 vertical rows.

Leaf Traces.—Primary vascular bundle divides to form leaf trace and reparatory strand; leaf trace with two protoxylem areas.

Locality and Horizon.—Linietta Springs, Junction City, Boyle County, Kentucky. Falling Run nodule zone and Bedford gray shale, Sanderson formation, Lower Mississippian (Kinderhook).

Material.—Four series of slides with preparator's numbers Dc-2-2 to Dc 2-5. U. S. National Museum, Washington, D. C.

This has the effect of removing *Callixylon* from the role of an index fossil of the Upper Devonian alone, and extends its range into Lower Mississippian where it mingles with a flora of considerably later aspect. A more detailed account of the numerous specimens of *Callixylon* affinity from comparable horizons, and age, and referred to here in the study of *C. brownii*, will appear elsewhere.

PROTOLEPIDODENDRON

A portion of a stem was found by Read and Campbell embedded in a phosphate nodule from the lower of the two nodule beds at the top of the Falling Run Horizon of the Sanderson formation a few hundred feet south of the type locality of the Jacobs Chapel shale. A series of five slides from this specimen taken in sequence but without record of intervals is available in the collections of the U. S. National Museum. The remaining portion of the original specimen, if any, has been misplaced.

This specimen furnished the basis for the description of a new species of *Protolepidodendron, P. microphyllum* Read and Campbell. The entire description is quoted here:

"1. Stem small, about 8 mm. diameter.
"2. Stele trilobed, the three lobes united to form a central column.
"3. Xylem mesarch, the protoxylem situated near the apices of the arms forming loops.
"4. Outer stelar tissues not preserved.
"5. Cortex parenchymatous and limited by a sclerotic hypodermis.
"6. Leaves scalelike both in aspect and in origin, parenchymatous.

"7. The leaves bifurcating a short distance above the point of attachment, exact outline unknown, but probably linear."

There is no discussion of this species. The reference to *Protolepidodendron* probably was based principally on the supposed trilobed nature of the stele, and by the nature of the apparently microphyllous leaves.

Certain points of exception to this description need to be noted.

1. The mesarch protoxylem points are situated deep in the arms of the stele and there are two areas in each arm at some levels. Perhaps this is due entirely to the division of the peripheral loop to form a leaf trace for the outermost of the two areas is less constant. In addition there are areas of protoxylem more deeply situated in the central axis of the column of primary xylem.

2. The outer stelar tissues are unusually well preserved.

3. The hypodermis consists of a few rows of cells which are smaller than those of the inner part of the cortex and are weakly sclerotic.

4. The leaves bifurcate more than once and through portions of their length are characterized by sclerotic tissue.

5. An even more significant exception is in regard to the "trilobed" nature of the stele.

The following discussion and accompanying illustrations afford evidence of a very different type of stele. In fact the conclusions form an adequate basis for the separation of this stem from others heretofore described with which it can be critically compared, thus necessitating the designation of a new genus to include it. The record of observations and a detailed description follow.

GENERAL CONSIDERATION OF **Guycampbellia,** gen. nov.

Stele.—The position of the protoxylem is mesarch as originally described, and loops are generally well-developed. The protoxylem elements are not easily discernible in these cross-sections, but they may be several in number. The principal protoxylem area is to be found centrally located in each ray or flange, i.e. about mid-way between the body of the stele and the tip of the arm, as seen in cross-section. An additional protoxylem area which does not have such clearly discernible loop structure is radially aligned nearer the tip as is the case with *Asteropteris* and certain zygopterids. In fig. 20 such a protoxylem area occurs very near the tip of the right flange of the portion of the stele present and in 20D, at a slightly higher level, it is nearly detached. The main loop in 20D appears somewhat enlarged but in the remaining higher sections does not appear to have given rise to the division of another trace to replace the one which became detached in the interval between sections shown in figure 20D and 20C. The detached vascular strand is to be found at some distance out in the cortex.

Another such protoxylem area is found in the left flange in fig. 20C. Here it appears to be very near the point of detachment from the main cen-

trally situated protoxylem area. In the succeeding figures its position changes very little, but in the highest section (20A) its early departure is suggested by the more attenuate nature of that arm and also by slight peripheral lengthening of the main loop.

An unusual situation obtains in regard to additional protoxylem areas in the axial portion of the stele. One of these is near the axis of the two arms (or flanges) though it may be basically a second strand or zone in the right flange. The other is more deeply embedded in the axis. In the original description this may have been interpreted as a loop comparable in form and position to the main loops in each of the two arms already discussed. It is our opinion however, that it constitutes a protoxylem area deeply embedded in the axial portion of the stele. Some reasons for this conclusion are (1) the fact that the metaxylem cells around this loop are not conspicuously radially arranged as in the two arms (figs. 13, 14); (2) the loop is smaller, more nearly comparable to the one to be seen at the axis of the two arms; and (3) the portion of the arm surrounding this zone is not expanded as in the case for the true arm or flange in all sections but it is about the same width as the narrowest part of the flange at the line of their attachment to the axis (fig. 13).

A reconstruction (fig. 20A) patterned after a possible interpretation of the complete stem is shown as being comprised of several discrete strands or plates as commonly found in *Cladoxylon*. From the small portion of the stele represented in the actual specimen it is not possible to give a more precise interpretation of its form. The feature of the additional protoxylem areas deeply embedded in the axis is not too far removed from the condition of the discontinuous loop areas and centrally oriented protoxylem points of *Cladoxylon mirabile* Unger. This is morphologically similar to continuous parenchymatous loop areas such as those found in *Asterochlaena*.

The basic form and appearance of the primary xylem is similar to that in the steles of certain stems of cladoxylalean affinity. The radial elongation of the flanges or "rays" of the stele and the probable division or origin of the outgoing traces from the terminal portion of the loop is a familiar condition in the *Zygopteridaceae* and *Cladoxyleae*. One marked difference from the *Cladoxyleae* is the detachment of a single trace ultimately to supply a leaf whereas in that group there are usually several traces derived from as many rays of the stele which supply such a leaf of the *Heirogramma* type. In *Asteropteris* a single radial extension of the stele gives rise to the outgoing leaf trace as clearly indicated in the often copied illustration of P. Bertrand (1912, p. 255, fig. 4).

There is no special form or outline of the vascular bundle of the leaf trace as it passes outward from the edge of the stele. This is in marked contrast to such forms as *Asteropteris* and the zygopterid ferns. The angle of departure of the leaf trace is entirely conjectural as we have no information as to the distance between the five successive thin-sections (figs. 20E-20A). As the bundles attain a near peripheral position in the cortex they become wider

tangentially and bifurcate once before the leaf itself becomes detached from the stem.

It can be seen in the series of camera lucida drawings (figs. 20E-20A) that the leaf traces follow a rather direct radial course from their origin at the tips of the stele outward through the cortex into the base of the leaf. It is therefore necessary to account for the source of the leaf trace or bundle which supplies the first leaf to the right (20E, L1) and the leaf to the extreme upper left (20A-20C). It is quite unlikely that they are derived from the two flanges of the central axis which remains in this longitudinally split stem fragment. It is reasonable to suppose that in the missing portion of the stem additional flanges of this stellate protostele existed in such a position as to have given rise to these leaf traces (fig. 20A). The stele would therefore not be "trilobed" but rather several lobed. Thus the interpretation of the stele as "trilobed," a character which probably formed a principal base for referring this specimen to the genus *Protolepidodendron*, cannot be continued.

The general size, outline and wall thickness of the cells of the primary xylem can be interpreted from figures 13 and 14. As no longitudinal sections are available, the nature of the thickening on the walls of the tracheids cannot be given.

Cortex.—Abutting directly upon the thin-walled cells of the tissue surrounding the xylem is a broad area of cortical tissue in which three zones can usually be recognized. Most of this area consists of a relatively uniform large-celled tissue. This tissue was probably relatively thin-walled in the living plant but by the nature of preservation it is difficult to attest to this. The bulk of the plants found in these deposits have parenchyma tissues which appear to be relatively thick-walled. It is believed that this is due, in part at least, to the post-depositional accumulation of translucent organic matter derived from the breakdown of protoplasm and some cell wall constituents. considerably augmented by accumulations of foreign organic material. The same general conditions of the parenchyma can be seen in figures of other plants described in this paper.

The tissue adjacent to the primary xylem is discontinuous. It is constituted of several layers of smaller thin-walled cells, rectangular in outline and elongated parallel with and appressed to the arms of the xylem as seen in transverse sections (figs. 13, 14). It is a discontinuous sheath as is evident from its position in figures 20E to 20A where it is indicated by stippling. It is present in the bays between the flanges of xylem in some sections but missing or extremely thin in other sections. It is also found to extend more or less to the tips of the flanges and even around them in some instances. This probably includes the phloem. The presence of a pericycle as distinguished from this tissue cannot be demonstrated.

Surrounding this tissue is a zone in which the cells are about one-half the diameter of those of the inner portion of the cortex but otherwise similar. The walls of these cells have the same thickness as those in the larger cells but because of their small size their walls appear thicker (figs. 15 and 18).

In the absence of longitudinal sections it is impossible to determine whether they are parenchymatous or more or less sclerotic. This layer averages six to eight cells in width and its inner margin is noted by a broken line in figures 20E and 20A.

Peripheral to this is a poorly delimited discontinuous hypodermis of three or four firm-walled cells whose diameter is approximately one-fourth the diameter of the larger cortical cells.

Epidermis.—The epidermis is made up of a single layer of very small cells with their longest axis directed tangentially, (figs. 18 and 19 at e). The cells are not everywhere discernible.

Leaves.—The stem is well covered with spirally arranged, sessile, decurrent leaves clearly seen in the several sections (figs. 20E-20A). On the right edge of figure 20E a conspicuous swelling marked L1 is interpreted as a decurrent leaf base. In the cortex internal to such leaf prominence an interesting development of large-celled tissue occurs which is indistinguishable from that of the main body of the cortex. The narrow zone of the smaller-celled outer portion of the cortex (not hypodermis), in addition to its normal position at the periphery of the stem, cuts across the base of the protuberance as indicated by the course of the broken line just internal to the leaf trace. Thus, in effect, at this plane the typical peripheral portion of the cortex completely surrounds a zone of large-celled cortical tissue including the leaf trace.

In the next higher section (fig. 20D) may be seen (1) the beginning of the separation of the leaf from the axis; (2) the partial division of the leaf trace; and (3) an indentation in the peripheral outline of the leaf base, an indication of its later bifurcation. In section 20C this leaf is entirely free from the axis, the trace is double, and the marginal indentation has developed into a deep cleft. This bifurcation is complete in the next higher section. Each of these primary divisions bifurcates once more so that each leaf has four ultimate segments. It should be noted here that the leaves appear to be appressed to the stem. The bifurcations are in the same plane and the divergence of each segment is at a low angle. This sequence may be followed by tracing leaf 3 (L3) through the four figures, 20E-20B, or leaf 5 throughout the entire series. Since the thickness of the material lost in sectioning is unknown, the length of the leaves is uncertain. As a single leaf can be traced through five sections it is estimated that they cannot be less than 6 mm. and are probably longer. They are about one mm. wide and about one-third as thick where they separate from the stem.

In the lower part of a leaf are two vascular bundles which were derived from the bifurcation of the leaf trace noted in section 20D, L1 and L5. The bundles are composed of eight to ten small tracheids, forming a cylindrical outline, some of which are smaller than others and may represent protoxylem although their position is not constant enough to warrant more than the suggestion that their position is mesarch. No phloem as such could be identified. Surrounding the tracheids is a sheath-like layer usually one cell in thickness and distinct in size and orientation from the peripherally adjacent leaf tissue

(fig. 16). The main tissue of the leaf at this level is a rather compact, uniform, large-celled mesophyll. Occasional patches of sclerotic tissue occur peripherally. The leaf is bounded by an epidermis of extremely small cells in which no stomata could be observed.

Following the first bifurcation of the leaf the divisions become rapidly reduced in size with little change in general form. Each division has a single very small bundle which is overshadowed by the development abaxially of a sclerotic strand which occupies an essentially central position in the leaf segment. This is the dominant tissue of the leaf tips following the second bifurcation (figs. 16 scl. tip, 17 scl.). The vascular bundles are rarely distinguishable at this level and it is certain that they do not extend to the leaf tips. The mesophyll gradually becomes reduced to a cell or two in thickness so that the tips of the leaf segments are, in effect, spinose (upper left, fig. 17 and lower right fig. 16).

Conclusion.—It is seen from the above description that in a number of respects this specimen departs rather widely from the established concept of *Protolepidodendron.* It is unfortunate that the detailed anatomy of this genus, known primarily from compression materials is not better known. However, certain major points of comparison and distinction may be made. The stele of *Protolepidodendron* is described (Kräusel and Weyland, 1932) as a protostele, triangular in outline, with either slightly concave or convex sides. The protoxylem is slightly embedded in the tips of the xylem arms. The stele in our specimen is either an actinostele with very deep embayments or a plectostele. Granting certain variation in internal morphology in relation to size, there is no reason to draw an analogy between this axis and that of *Protolepidodendron* on this basis. The rather robust protostele of *Protolepidodendron* is fundamentally different from this radiate or plectostelic type.

While the protoxylem is mesarch, as it also is in *Protolepidodendron,* there is a fundamental difference in the deep position of the protoxylem and loop formation in this stele. Beyond this a further distinction lies in the fact that there is more than one protoxylem area in each radial flange of this stele and also in the occurrence of additional protoxylem areas more deeply situated in the central or connecting axis. This gives the effect of a medium zone differentiated from the peripheral areas of each xylem band, somewhat after the fashion of *Asterochlaena,* with a slight radial orientation of the metaxylem cells circumscribing this medial area.

The size and arrangement of leaves and form of the leaf bases compare favorably with those generally attributed to *Protolepidodendron.* The leaves in this specimen, however, are closely appressed to the axis rather than being widely divergent as given for *Protolepidodendron,* and they bifurcate not once but twice and in the same plane, the first division occurring very near the base of the leaf and the second following immediately. Divisions of a single leaf trace continue into the bases of the ultimate divisions of the leaf but do not extend far into the spinose extremities.

While recognizing similarities between this plant and *Protolepidodendron*

the fundamental differences make its retention in that genus untenable. We therefore have proposed the new genus *Guycampbellia* to include this species. The generic and emended specific descriptions follow.

Guycampbellia, gen. nov.

Fossil plants of uncertain affinity known from petrifactions with small, cylindrical stems, densely clothed with small, sessile, decurrent, spirally arranged, twice-forked, spine-tipped leaves. A single cylindrical leaf trace arising from the outer loop of an arm of the stele traverses the cortex at a wide angle and divides in the leaf base, each bundle dividing again to supply each of the four somewhat unequal slightly spinose ultimate segments of the leaf. Stele either actinostelic or plectostelic with narrow flanges and deep embayments. Protoxylem mesarch, deeply embedded, usually more than one area in each flange, with occasional deeper areas.

Type of genus—*Guycampbellia microphylla* (Read and Campbell) Hoskins and Cross, emend.

The name is given in recognition of Mr. Guy Campbell, stratigrapher, who is responsible for the discovery of this and many other plant-bearing beds of the black shales and for the extensive field assistance and advice on the geology and distribution of this flora.

GUYCAMPBELLIA MICROPHYLLA (Read and Campbell) Hoskins and Cross, emend.

1939. *Protolepidodendron microphyllum* Read and Campbell, Amer. Midl. Nat. 21 (2): 435-453. p. 443, pl. 3, figs. 1, 2.

Habit.—A single specimen known, split tangentially from the entire stem, representing about one-third to one-fifth the total diameter. Stem originally cylindrical, about 5 mm. in diam., with numerous spirally arranged leaf bases forming conspicuous protuberances on surface.

Stele.—Two arms or flanges of primary xylem seen in the single specimen known, representing a portion of a plectostelic or actinostelic vascular cylinder; flanges each one-half to 1 mm. long as seen in cross-sections, bluntly rounded to attenuate in outline, slightly wider in middle with a large protoxylem (loop) area occupying a near central position in each flange, a second smaller and less loop-like area generally present nearer the periphery (from which the leaf traces are given off), and occasional, similar small protoxylem areas lying more deeply embedded. A zone of discontinuous tissue peripheral to xylem, two to four cells thick, present in bays and extending along sides of flanges and around tips of arms in places may represent phloem.

Cortex.—Indistinctly divisible into three zones; an inner large-celled cortical tissue surrounding the stele, a smaller-celled tissue 6-8 cells wide peripheral to this and an outer patchy zone of hypodermis comprised of cells about one-fourth the diameter of the large inner cells of the cortex.

Leaves.—Closely appressed, probably 6-10 mm. long and forked twice in a single plane, flattened and slightly angular in outline, about one mm. broad and one-half mm. thick at base; primary and secondary divisions of leaf occasionally unequal. The twice-forked leaves show an increasing amount of sclerotic tissue toward their apices and were probably spinose. A single leaf trace circular in outline, given off radially from a single flange of the xylem, passes directly outward and enters the base of the sessile, decurrent leaf and divides once before the leaf becomes entirely free of the stem and again almost immediately thereafter. The outer small-celled zone of the cortex cuts across the leaf base as well as around it marginally and encloses a zone of larger-celled parenchyma and the leaf trace.

Material.—5 transverse thin-sections from stem in collection of U. S National Museum.

Horizon and Locality.—Lower nodule bed of upper part of Sanderson formation, New Albany shale (Mississippian portion), about 100 yards southwest of type locality of Jacob's Chapel shale, in bed of Slate Run, Floyd County, Indiana.

REIMANNIA

The genus *Reimannia* was founded by Arnold (1935) for a single species, *R. aldenense*, based on several petrified specimens from the Ledyard member of the Ludlowville formation (Middle Devonian) of New York. Read and Campbell (1939) described a second species, *R. indianensis*, on the basis of a single petrified stem from the Falling Run horizon of the Sanderson formation (L. Mississippian), New Albany shale, near New Albany, Indiana. This small stem is embedded in a phosphate nodule, the matrix of which is principally made up of an interwoven mass of siphonous cells similar to but distinct from *Prototaxites* (*Nematophycus*). The very brief description is quoted in full:

"1. Stem small, 2 to 3 cm. in diameter in the specimen seen.
"2. Stele small, centrally located, T-shaped, amphicribral.
"3. Xylem mesarch, forming well-defined loops near the apices of the arms.
"4. Outer stelar tissues poorly preserved.
"5. Cortex parenchymatous, with outer tissue inclined to be sclerenchymatous.
"6. Appendages unobserved."

There is no discussion. The diameter of the stem is intended to be 2 to 3 millimeters, not centimeters. The single camera lucida tracing, which is given without explanation, showing the outline of the stele, the position of some of the protoxylem areas, a line internally delimiting the zone of preserved cortex and the outline of the stem is inadequate for comparison of essential characters with the previously described species.

Three of the four original thin sections and the specimen were lent to us for examination by the U. S. National Museum. In reviewing below the characteristics of *Reimannia indianensis* in comparison with those of the type species, *R. aldenense*, the much greater size ratio of stele to cortex, the outline of the T-shaped stele with attenuated tips and deep angular embayments, the

complete absence of leaf traces in the cortex and any evidence of leaf formation or branching whatsoever in the New Albany shale species, will appear to be sufficient evidence to warrant the exclusion of this specimen from the genus *Reimannia*. Thus any inferences of floristic association or stratigraphic connotation previously raised because of the selection of the genus *Reimannia* to house this specimen must be rejected. In the absence of any known genus to which this specimen may be referred we propose a new genus to include it.

Reimanniopsis, gen. nov.

Stele.—The outline of the primary xylem (figs. 2 and 6) is roughly T-shaped in the figures given, with the flange forming the stem of the T being shorter than the flanges or arms at the top. The longest diameter is approximately one millimeter which is slightly more than one-half the diameter of the axis.

The several transverse sections show considerable variation in the length of these stelar flanges and the one forming the stem of the T is the longest of the three at some levels. As in figure 6 the upper arms are relatively straight but in some sections they are recurved inward (downward) toward the stem of the T-shaped stele. There is evidence of a shallow depression opposite the upper end of the vertical arm in figure 6, CL, where the two arms of the T join. In some sections this furrow is occupied by cells of small caliber. Where this is most noticeable the outline of the xylem is somewhat Y-shaped, accentuated by the slightly recurved nature of the arms.

Near the tips of the upper two arms of the T-shaped xylem are two slightly elongated spaces where tissues have disintegrated which are interpreted as protoxylem areas or loops (fig. 6). The protozylem cells can be only tentatively identified for the cells of each area are generally broken down. In the arm forming the stem of the T only one such area has been identified. That these spaces were in reality occupied by protoxylem is indicated by a tendency for the cells surrounding these areas to approach radial alignment in their disposition (fig. 6). The metaxylem cells are much smaller near the tips of the arms than in the center.

It is difficult to offer a satisfactory explanation for two protoxylem areas in the tips of the flanges of the primary xylem in the absence of any evidence of the emission of any traces from this stele. Consideration has been given to the possibility that the two spaces are actually from a single elongated loop but this seems unlikely.

There is no secondary xylem and the tissues immediately surrounding the primary xylem are completely disintegrated.

Cortex.—The cortex is a compact, homogeneous tissue with a gradual reduction of size of cells toward the periphery. The outer margin is delimited by the thick walled hypodermal cells which form a sort of rind three to six layers of cells thick.

Comparison with Reimannia aldenense Arnold.—Reimannia was originally described by Arnold (1935) from several petrified specimens preserved in

marcasite concretions. The description of the type species, *R. aldenense*, is based principally upon one small specimen which showed the best preservation. Unfortunately the type specimens have partially disintegrated and therefore are quite unsatisfactory for comparison. Professor Arnold kindly lent us for comparison the two excellent negatives of the original picture illustrating the type species (figs. 1, 6 and 9, pl. 1, Arnold, 1935).

The stem of *R. aldenense* is somewhat angular in outline, probably related to the frequency of relatively large leaf bases. It is apparent that the basic form of the xylem is triangular with the protoxylem slightly mesarch at each of the three angles. There is no secondary wood. In the column of primary wood the angles are rounded and blunt with the sides scarcely or not at all concave. Even though this xylem strand is quite minute, about seven-tenths of a millimeter along one side, and occupies but approximately one-sixth of the total diameter of the stem, it is compact and homogeneous. It seems reasonable to suggest that its triangular form is constant and not merely related to its small size. In the figured specimen one of the three angles is laterally extended and terminates in an apparent loop. This elongated arm with its accompanying loop structure no doubt represents a phase in the formation of a leaf trace which could be expected to be free from the central stele at a higher level. The occurrence of another protoxylem area not indicated in Professor Arnold's illustrations, which occupies a position in the extended arm comparable to that in the other two arms, and the position of two leaf bases of different sizes opposite the other two arms of the xylem at lower levels, give strength to the idea that leaf traces are given off regularly from each of the three angles and apparently in a spiral fashion. Furthermore Professor Arnold reports the occurrence of occasional small bundles in the cortex which resemble leaf traces.

Affinities.—The systematic position of *Reimanniopsis* is uncertain. It bears some resemblance to a number of other genera. For instance, the detail of the attenuate arms of primary xylem and the nature and organization of the cells recall the genus *Arachnoxylon* Read (figs. 11, 12). There two protoxylem loop areas are to be found in some of the flanges (fig. 12). The general form of the stele of that genus (fig. 11), however, precludes the assignment of the New Albany species to *Arachnoxylon*.

There is a superficial similarity of *Reimanniopsis* to some of the "petiole traces" of *Tetrastichia bupatides* (Gordon, 1938, pl. II, fig. 9 and pl. V, figs. 33-36). There are basic differences which prevent congeneric assignment. 1) The cortex of *Reimanniopsis* is homogeneous and is delimited peripherally by a uniform hypodermis 3-6 cells thick. The cortex of *Tetrastichia* not only includes specialized areas, possibly ducts ("sclerotic nests" of Gordon), but has an irregular peripheral hypodermis approaching the sparganum-type (Gordon Collection slide 2006). 2) The protoxylem areas of the "petiole trace" of *Tetrastichia* are less deeply imbedded than in *Reimanniopsis*. 3) The tips of the xylem arms of the petiole bundle of *Tetrastichia* become tangentially enlarged accompanied by immediate bifurcation. Each part of the bifurcation possesses a protoxylem area. This forked tip with the two proto-

xylem areas becomes detached as a unit from the petiole trace resulting in a clepsydroid structure. In *Reimanniopsis* the arms of the xylem are more or less attenuated with no indication of enlargement or bifurcation, the departing traces originating in an entirely different manner.

Additional information is required before *Reimanniopsis* can be assigned to a systematic group with assurance.

REIMANNIOPSIS INDIANENSIS (Read and Campbell) Hoskins and Cross

1939. *Reimannia indianensis* Read and Campbell, Amer. Midl. Nat. 21 (2): 435-453, p. 443, pl. 4, fig. 5.

Description of species.—Same as given for genus.

Material.—Three thin sections and the remaining portion of the specimen in the collection of the U. S. National Museum.

Horizon and Locality.—Nodule bed, upper part of the Sanderson formation, New Albany shale (L. Mississippian), near New Albany, Indiana.

ASTEROXYLON

Two well established species of *Asteroxylon*, *A. Mackiei* Kidston and Lang and *A. elberfeldense* Kräusel and Weyland, are known from the Middle Devonian only. In 1939, Read, in Read and Campbell, recorded a third species, *A. setchelli* from the basal Mississippian black shales of New Albany, Indiana. This reported occurrence of the genus from these younger beds is of such interest that a review of the material on which *A. setchelli* was based is presented below, and is compared with Read and Campbell's brief description (p. 442) which follows in full.

"1. Stems small, the specimens seen less than 5 mm. in diameter.
"2. Stele stellate, consisting of five radiating arms centrally united to form a relatively stocky solid cylinder.
"3. Phloem and outer stelar tissues problematical but probably concentric.
"4. Protoxylem exarch to slightly immersed.
"5. Outer tissues parenchymatous as observed, with some traces of a thick-walled hypodermis."

A photograph showing general topography (fig. 2, pl. 4, Read and Campbell, 1939) completes their account of the species.

Nine thin sections, all transverse, in the collection of the U. S. National Museum which obviously formed the basis of the record, were kindly placed at our disposal for investigation. Six of the nine are in series although the spacing between them is unknown. A seventh belongs to the same series but its position relative to the others cannot be determined. Read and Campbell's description and figure and our figures 21 and 24 are based on this series. One section each from two additional specimens (figs. 25, 26) completes the collection. Although showing some general similarity with the main series, especially the specimen shown in figure 25, these two differ from each other and from the main series and it should be understood that possibly one (fig.

25) and certainly the other (fig. 26) belong to a different genus than that shown in figure 21. Read and Campbell (1939) did not include these two specimens in their account of the species except to record the occurrence of *Asteroxylon setchelli* from two localities (p. 441). Which specimen came from which of these localities cannot be determined, nor is it significant as both localities are from essentially the same horizon. The petrifactions from which the various sections were made are not available.

Our review of the morphological features which can be determined from the material at hand indicates that the plant described as *Asteroxylon setchelli* cannot properly be retained within that genus and that a new genus must be designated to include it based on the following observations and description.

Stenokoleos, gen. nov.

General Features.—The stem is slightly flattened, small, not exceeding 4.3 mm. in greatest diameter. Figure 21 shows the outline and general organization of the tissues which have been preserved. Figure 24A is a camera lucida tracing of the stele and cortex. Areas outlined by broken lines are drawn in detail in figures 24B, C, and D. It will be observed that the stelar tissues occupy about three-fifths of the total diameter of the stem, and that all of the tissues lying between the xylem and cortical tissues are absent.

The Stele.—The stele has been described as stellate; its form in transverse section may well have been a basis for assigning this plant to the genus *Asteroxylon*. Actually the stele appears to be more nearly four angled, with a tendency for the arms to bifuracte. In the specimen itself, two of the four arms are slightly elongated and somewhat divided. The stelar column would then be deeply fluted with four main ribs, two of which are grooved.

Protoxylem.—The protoxylem has been described as "exarch to slightly immersed." Without exception it is mesarch with several cells between the protoxylem and the periphery of the stele (figs. 21, 22 and 24 B, D). The protoxylem area is relatively large and conspicuously set apart by smaller cell size and suggests the "loop" situation in plants of cladoxylalean affinities, although the comparison must not be carried too far. In addition to a protoxylem area in each arm or in each bifurcation there are two additional areas of similar appearance deeply embedded in the stele, possibly additional protoxylem areas (cpx, fig. 22, 24A, outlined by dotted lines). These features are not characteristic of *Asteroxylon,* at least as illustrated by *A. mackiei* (fig. 23).

Metaxylem.—There is a faint alignment of the main body of tracheids relative to the periphery of the stele giving the effect of a slightly radial arrangement. This is due to the fact that the tracheids generally are not essentially cylindrical but are, in transverse section, somewhat elongated with their longer diameter being directed toward the periphery of the stele (figs. 21, 22 and 24C). The tracheids are of fairly uniform size, varying from 50 to 75 microns in longer diameter, although occasional cells as small as 35 or as large as 100 microns occur. One receives the impression that the metaxylem is much less uniform than that of *A. Mackiei.* Surrounding the main

body of tracheids is a peripheral layer of smaller tracheids two to three cells wide which is clearly set off by the abruptness of the reduction of cell size to 22 to 30 microns. The assumption is that we are dealing with tracheids only, although both the nature of petrifaction and the limitation of sections to transverse makes final proof impossible.

Cortex.—The cortex of *Stenokoleos* is relatively narrow, essentially uniform, and has no indication of periderm. Except at the periphery where the outer three or four rows of cells diminish rapidly to a diameter of 20 to 25 microns, the cells are rather uniformly large, from 90 to 110 microns in diameter, with occasional much smaller cells. The epidermis is poorly preserved or missing (fig. 21).

In general appearance the cortex is not greatly unlike that of some of the coenopterids. The relatively thick cortex of *Asteroxylon Mackiei,* well differentiated into inner, middle and outer cortex, presents an entirely different picture and is in no way comparable.

Leaf Trace.—One of the outstanding characteristics of *Asteroxylon Mackiei* is the occurrence of numerous leaf traces (fig. 23, Lt). In the series of sections on which *Stenokoleos* is based no leaf traces of any kind occur. Nor can the absence of leaf traces be correlated with the possibility that we are dealing with a *Hostimella* portion of an *Asteroxylon* axis (cf. *Asteroxylon elberfeldense*) as the recorded anatomy of such axes is quite distinct from that shown here. If, however, the single section of a second specimen (fig. 25) does represent another example of *Stenokoleos* then a few more details may be given. It is certain that the organ not yet separated from the stem is a foliar member and not a branch or dichotomy of the axis. Two vascular bundles with internal protoxylem (px, fig. 25) are separated by parenchyma and each presents an appearance not too dissimilar to the areas immediately surrounding the protoxylem in *Stenokoleos* as seen in figure 22. The preservation of the stele of this specimen is insufficient to carry the comparison further than to call attention to the similarity in general of the stele and cortex to *Stenokoleos.*

Conclusion.—A comparison of the protoxylem, metaxylem, cortex, form of stelar column and ratio of stele to entire stem of the New Albany specimen with the comparable structures of *Asteroxylon* shows significant differences in each category such that its retention within the genus *Asteroxylon* becomes untenable.

Comparison with Tetrastichia.[2]—We have referred above to the superficial similarity between *Reimanniopsis* and the petiole divisions of *Tetrastichia.* There is also a superficial similarity between *Stenokoleos setchelli* and the stems of *Tetrastichia bupatides* which may actually indicate some larger group relationship.

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2 This topic was completed following discussions with Professor John Walton, University of Glasgow, and after critical examination of the slides of *Tetrastichia* in the Gordon Collection at King's College, London, made available for study through the kindness of Mr. N. F. Hughes, Bedford College, London.

Differences, however, are readily demonstrable which require generic distinction. 1) Cambial activity in *Tetrastichia* results in a thick zone of secondary xylem; there is no secondary xylem in *Stenokoleos*. 2) The protoxylem in *Tetrastichia* is very slightly immersed in the "petiole traces" not yet detached from the axis; the protoxylem is more deeply immersed in *Stenokoleos*. 3) There is continuous bifurcation of the xylem arms in *Tetrastichia* resulting in many petiole traces; no leaf traces were observed in *Stenokoleos*. 4) The cortex of *Tetrastichia*, marked by radial bands of sclerenchyma, is "sparganum-like" in appearance; this does not occur in *Stenokoleos*. 5) The cortex of *Tetrastichia* has specialized areas called sclerotic strands by Gordon (these may be filled ducts); the cortex of *Stenokoleos* is relatively homogeneous.

Regardless of general relationships which may be established in the future between the types of structures shown in several orders of branching of such plants as *Tetrastichia*, *Stenokoleos* and *Reimanniopsis*, *Stenokoleos* and *Tetrastichia* are generically distinct.

We propose the new genus *Stenokoleos* to include this New Albany shale specimen. The name is given in reference to the narrow cortex.

Type of Genus.—*Stenokoleos setchelli* (Read and Campbell) Hoskins and Cross, emend.

STENOKOLEOS SETCHELLI (Read and Campbell) Hoskins and Cross

1939. *Asteroxylon setchelli* Read, in Read and Campbell, Amer. Midl. Nat. 21 (2): 435-453, p. 442, pl. 4, fig. 2.

Description of Species.—Same as given for genus.

Material.—Seven transverse thin-sections of stem in collection of the United States National Museum. Reference to two additional sections of two other plants from the same collection.

Horizon and Locality.—Nodule bed and plant bed, upper part of Sanderson formation, New Albany shale (Mississippian portion), Floyd County, Indiana.

SUMMARY

Four species reported from the New Albany shale flora of Lower Mississippian age representing genera which are elsewhere known only from the Devonian have been reviewed, their brief original descriptions emended, and they have been transferred to the following genera:

1) *Callixylon brownii.*—Based on the occurrence of wood from several localities in the Lower Mississippian having the radial alignment of discontinuous pit groups characteristic of the genus *Callixylon*, the probable occurrence of this characteristic in the specimen reported as *Pitys brownii*, and the conformation of that species otherwise to *Callixylon* anatomy, we do not hesitate to consider *Pitys brownii* a representative member of the genus *Callixylon*. This has the effect of removing *Callixylon* as an indicator of the Devonian age of the rocks within which it may be found.

2) *Guycampbellia microphylla.*—We have transferred this species from *Protolepidodendron* as its organization and structure are not compatible with our knowledge of that Lower and Middle Devonian genus.

3) *Reimanniopsis indianensis.*—This species, reported as *Reimannia indianensis,* differs in a number of significant ways from Arnold's species, *R. aldenense,* on which the genus was based. We have, therefore, transferred *Reimannia indianensis* to *Reimanniopsis.*

4) *Stenokoleos setchelli.*—A comparison of the anatomy of this species with previously described species of *Asteroxylon,* especially with *A. Mackiei,* prompted its removal from that genus. We have proposed the genus *Stenokoleos* to receive it. *Asteroxylon* is not known from beds younger than Middle Devonian.

It may now be emphasized that evidence of the Devonian age of the New Albany shale flora which has been supported by the selection of well established Devonian genera to house some of its species must be denied. The species considered here are but a part of a rather extensive flora, quite distinct in character from the known Upper Devonian floras on the one hand, and from the later Mississippian floras on the other. Until further investigation breaks down the apparent isolation of this unique assemblage of basal Mississippian plants, a few members of which we have considered above, the relationships of the New Albany shale flora both to its progenitors of Devonian age and to its progeny of Later Mississippian age remain unknown.

ACKNOWLEDGMENTS

We wish to express our sincere appreciation to Dr. G. Arthur Cooper, U. S. National Museum and to Dr. J. B. Reeside, Jr., U. S. Geological Survey, for making available for these studies many specimens in the U. S. National Museum; to Professor C. A. Arnold, University of Michigan, for negatives of *Reimannia;* to Dr. H. R. Muegel, University of Cincinnati, for the suggestion of certain generic names; and to Mrs. Maxine Abbott, University of Cincinnati, for aid in the preparation of the plates.

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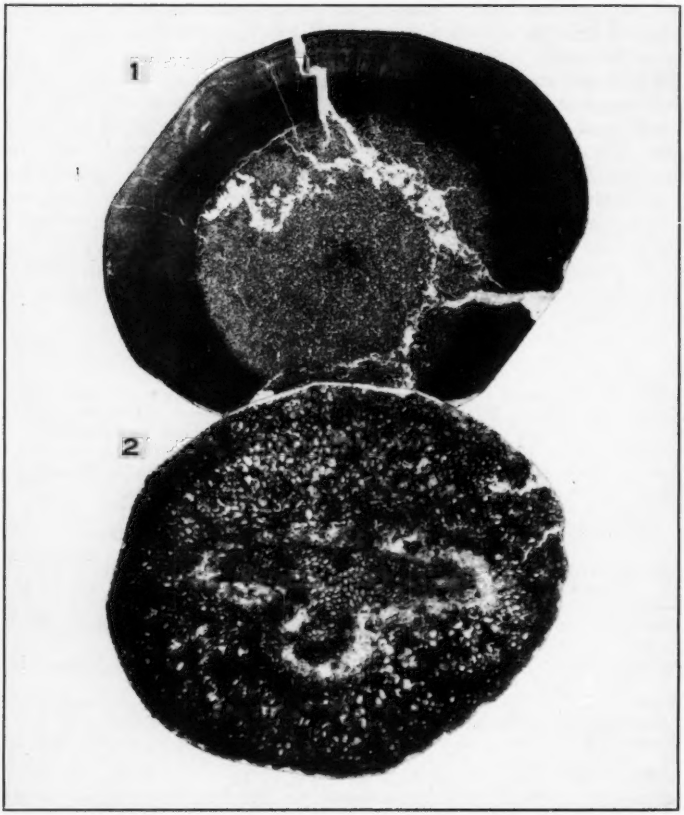


Figure 1. *Callixylon brownii* (Read) Hoskins and Cross. Diameter of pith 15 mm.
Figure 2. *Reimanniopsis indianensis* (Read and Campbell) Hoskins and Cross. Showing outline of stem and tissue orientation. Total diameter of stem about 2.5 mm. Tissue between main body of cortex and T-shaped stele not preserved.

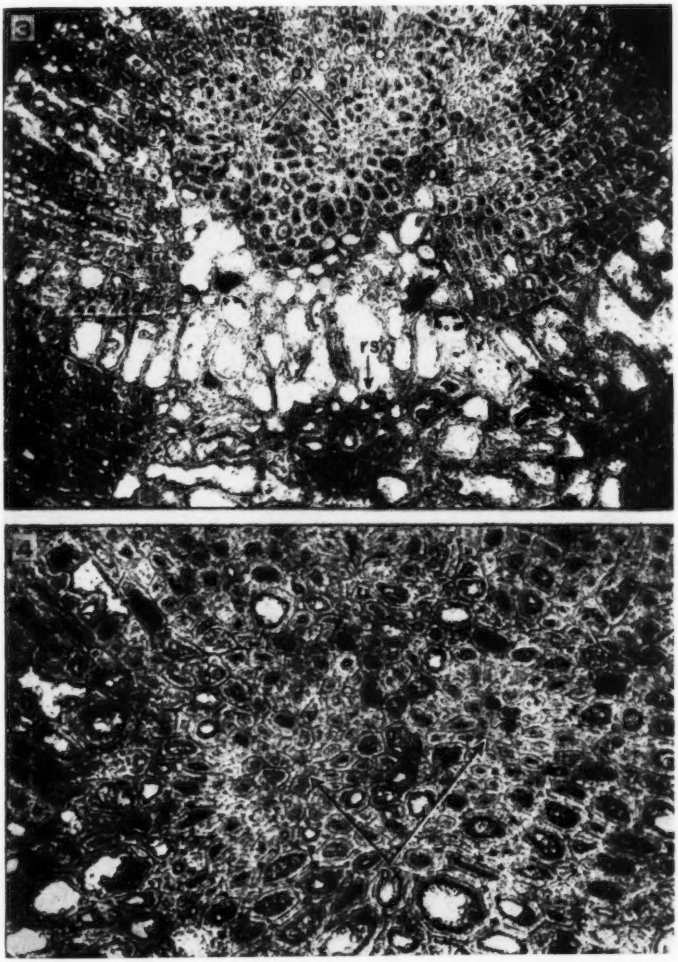
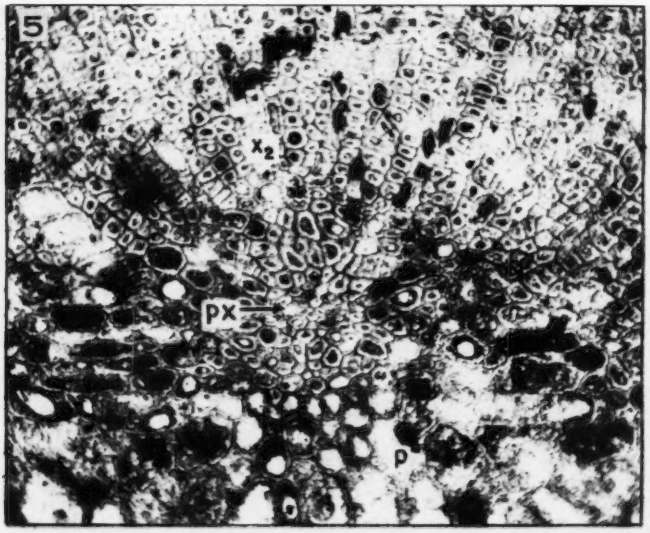


Figure 3. *Callixylon brownii.* Leaf trace with two protoxylem points (px) and reparatory strand (rs).

Figure 4. Circum-medullary bundle of *Callixylon brownii.* One of the few with two protoxylem areas (px) and probably correlated with the development of a leaf trace.



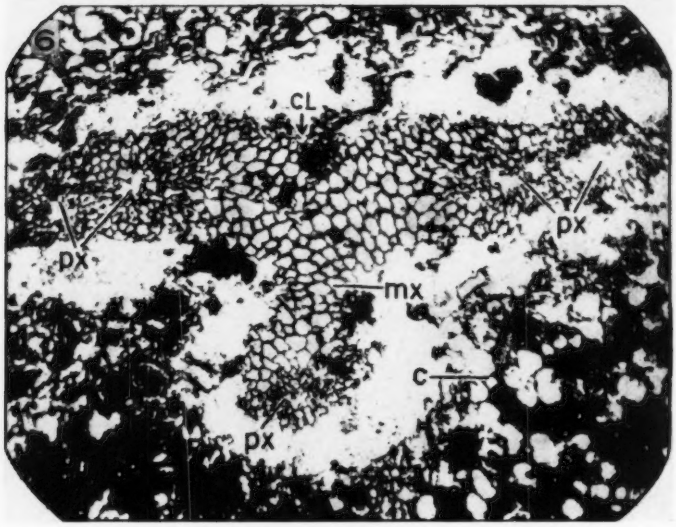
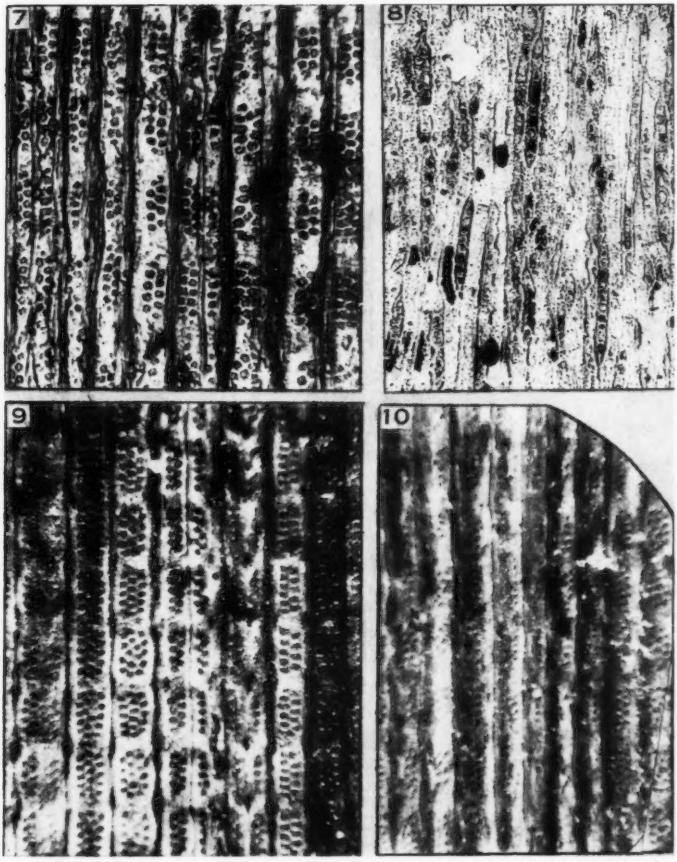


Figure 5. Usual circum-medullary bundle of *Callixylon brownii* with single protoxylem point (px); x_2, secondary wood; p, pith.

Figure 6. Enlarged detail of stele of *Reimanniopsis indianensis* shown in figure 2. px, protoxylem areas; mx, metaxylem; cl, cleft; c, cortex.



Figures 7, 9 and 10. Radial sections of *Callixylon* showing the characteristic radial alignment of discontinuous pit groups. Figure 7. *C. Newberryi* from the Upper Devonian black shale of Kentucky. Figure 9. Undescribed species from the lower Mississippian (Upper New Albany) of Crab Orchard, Kentucky. Figure 10. Undescribed species from type locality of Kinderhook series (L. Miss.), Illinois.

Figure 8. *Callixylon brownii*. Tangential section showing characteristic low uniseriate rays.

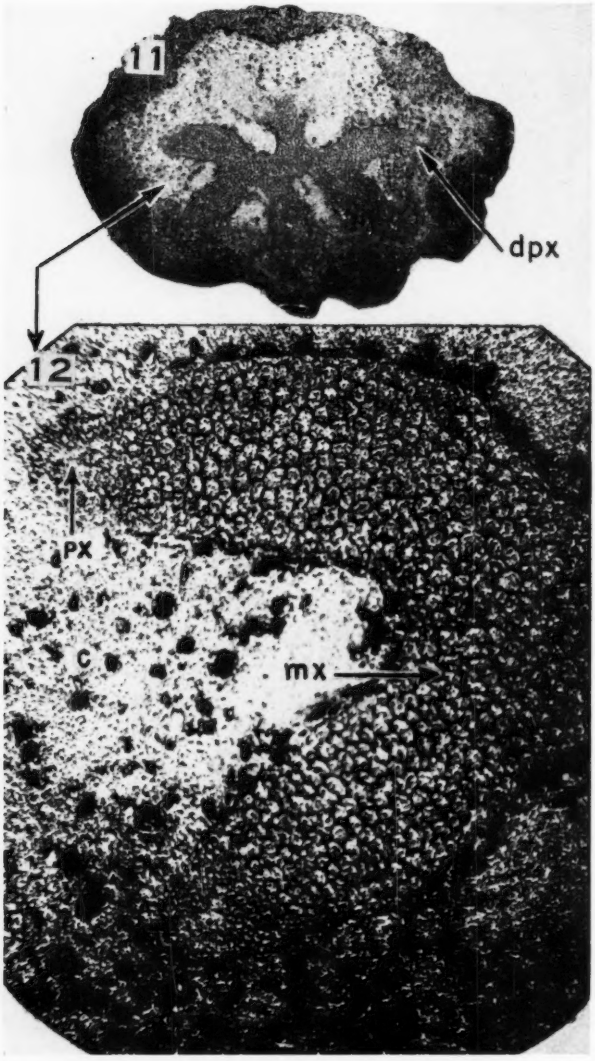


Figure 11. *Arachnoxylon Kopfi* (Arnold) Read. dpx, double protoxylem point. Discussion in text.

Figure 12. Enlarged detail of figure 11. px, protoxylem; mx, metaxylem; c, cortex.

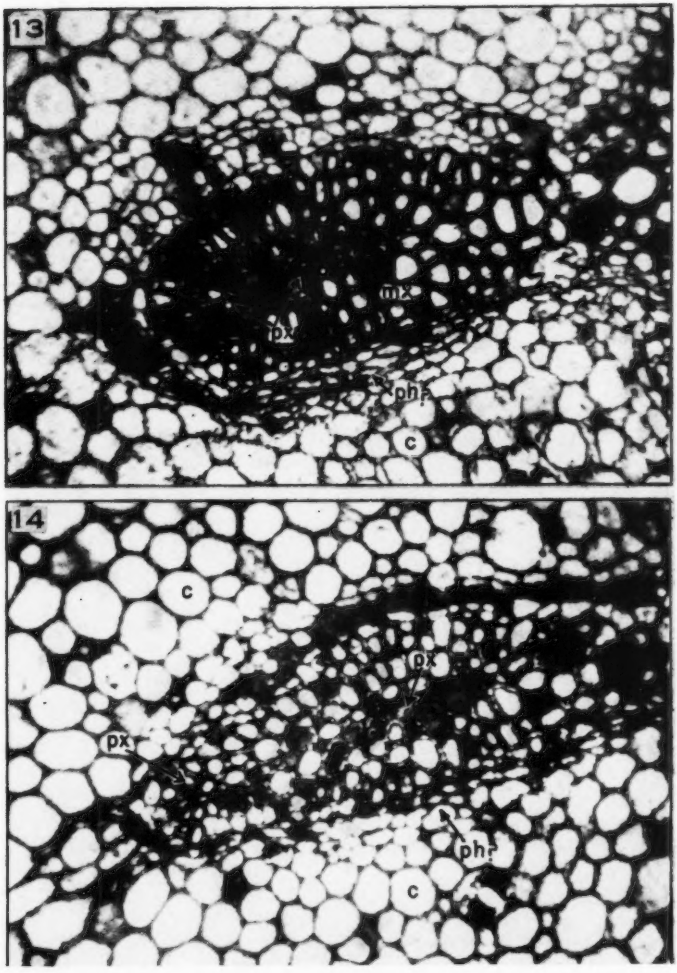


Figure 13. Transverse section showing a flange of the primary xylem of *Guycampbellia microphylla* and the surrounding tissues (ph) which may be interpreted as phloem. The tip of the flange is to the left. px, protoxylem; mx, metaxylem; c, cortex.

Figure 14. Transverse section showing a more attenuate flange of primary xylem with the most peripheral protoxylem strand (px, left) just below the level where it departs as a leaf trace. The central position of the elongate loop area and the radial arrangement of cells of metaxylem surrounding it should be noted. ph, phloem; c, cortex.

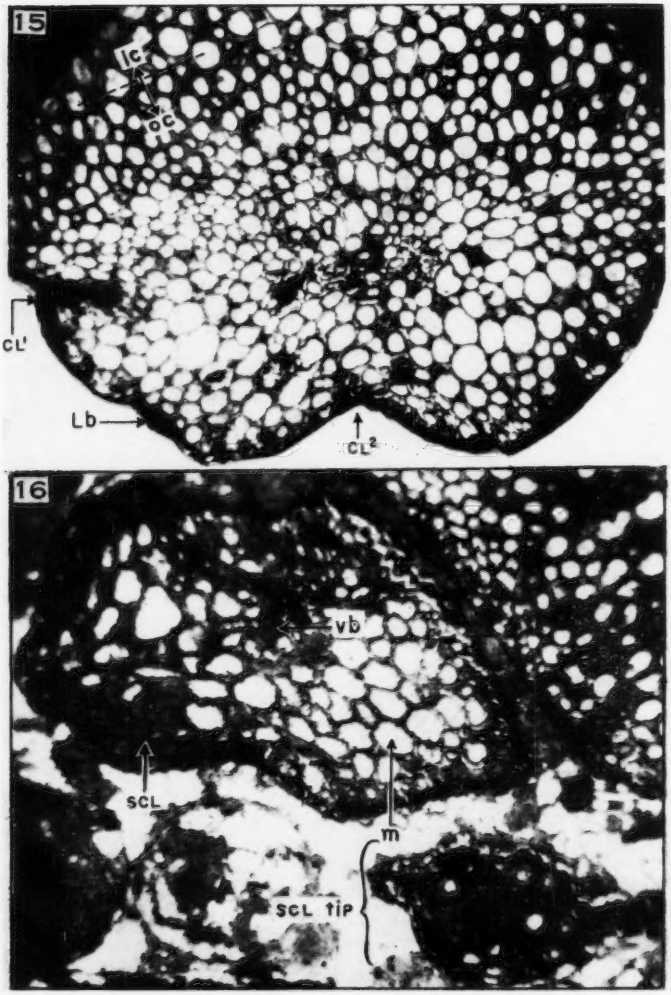


Figure 15. Transverse section of leaf base (lb) and portion of periphery of stem of *G. microphylla*. The division of the bundle is nearly complete here and is seen as a laterally extended dark area internal to the furrow developing at cl^2 which precedes bifurcation of the leaf. The cleft at cl^1 is an actual separation of the edge of the leaf base from the stem. A few cells of the inner cortical area (ic) are seen at the upper left and center, and in the central portion of each lobe of the developing leaf base. A broad zone of smaller outer cortical cells (oc) occupies a position internal to the leaf base protuberance, and a thin layer of this tissue, indistinctly separated from or mixed with the slightly sclerotic hypodermal cells, outlines part of the leaf base.

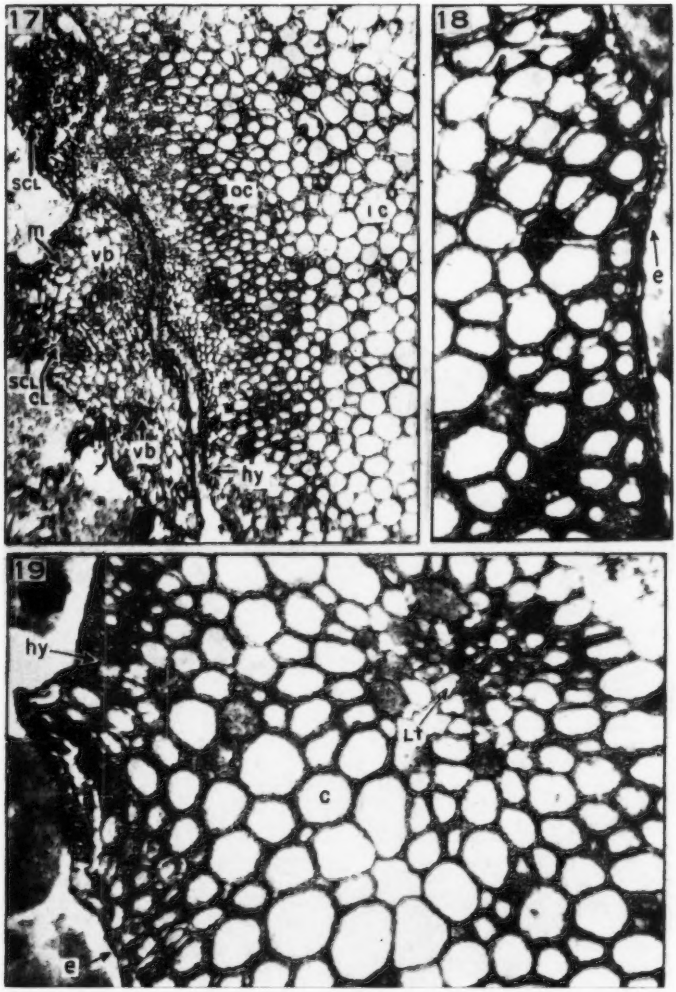


Figure 16. Transverse section of a leaf of *Guycampbellia* just above the level of the first division showing one of the resulting segments. Here the mesophyll (m) is relatively broad and the sclerotic tissue is developed in only one area (scl). The vascular bundle is only slightly different in character from that seen in figure 17. The sclerotic leaf tip (scl. tip) sectioned near the tip of one of the ultimate segments, shows no vascular bundle.

For explanation of figures 17, 18 and 19 see page 715.

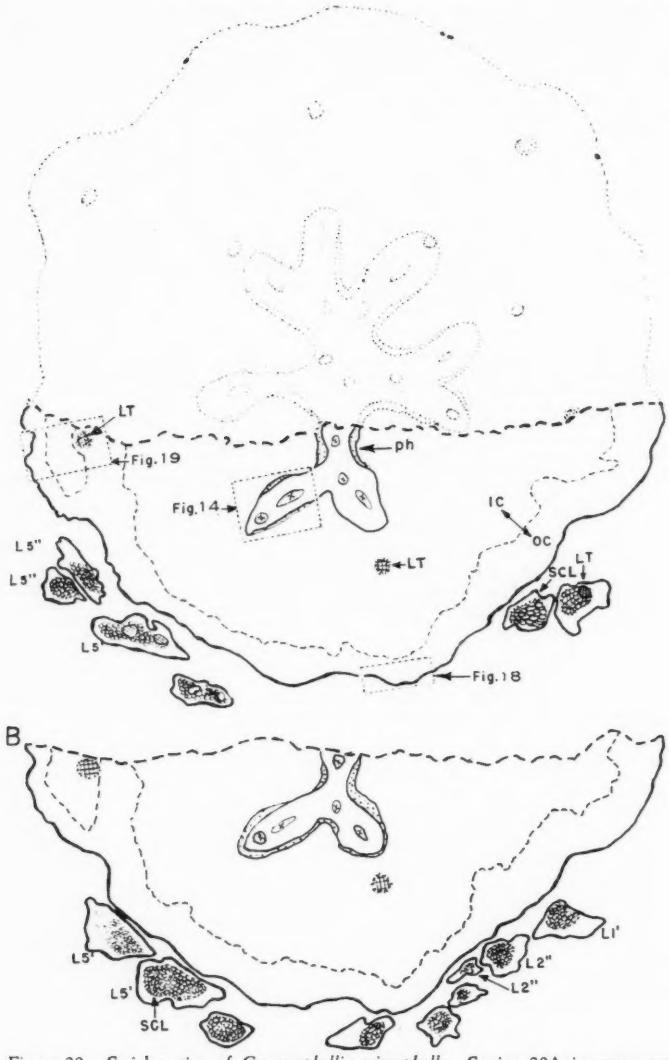
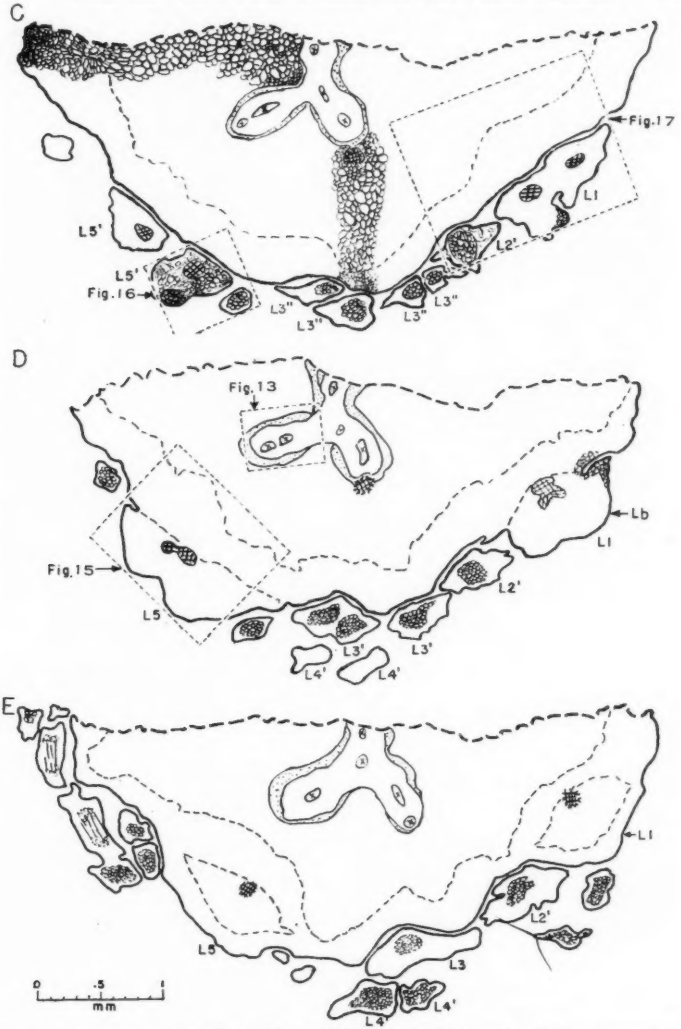


Figure 20. Serial section of *Guycampbellia microphylla*. Section 20A is uppermost. The intervals between sections are unknown.

The bundle in the right arm at the tip of stele in 20E passes outward, is nearly free from the stele in 20D and is further out in the cortex in consecutive sections.

The bundle in the left arm (20E) is single and is distinctly divided in 20D. It is



closer to the apex or edge of the flange of the stele in 20A, and possibly the attenuate nature of the ray of stele and near peripheral position indicates it will have separated from the stele in slightly higher section. This detail is shown in figure 14.

Bundles seen near the periphery of stem on the right side of 20E and at upper left edge of 20A do not appear to have been derived from the portion of the xylem present. The position of these indicate additional arms or flanges such as shown in the hypothetical reconstruction in 20A.

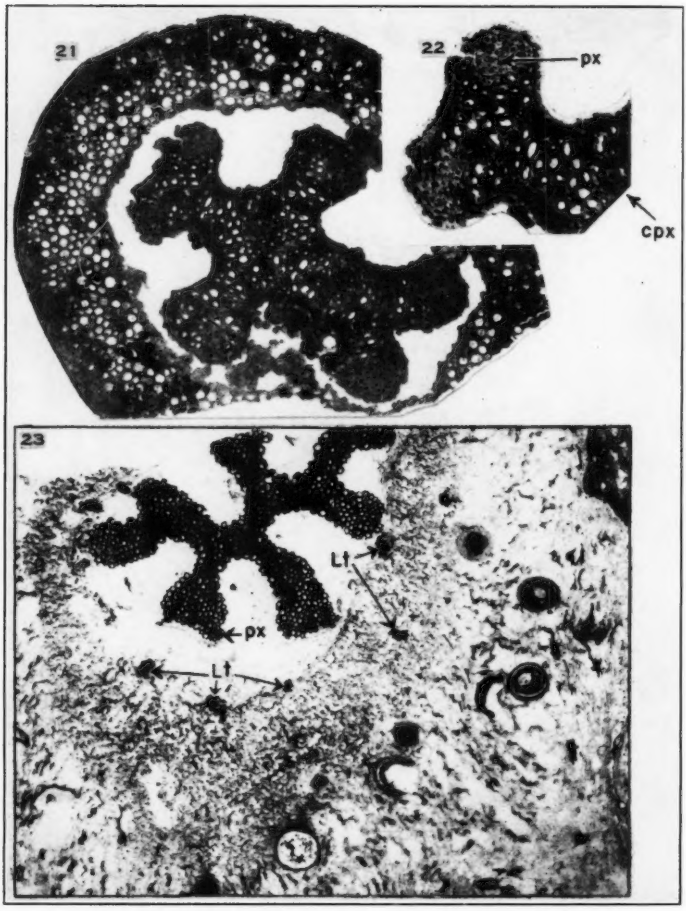


Figure 21. *Stenokoleos setchelli* (Read and Campbell) Hoskins and Cross. Transverse section showing general organization of tissue.

Figure 22. Enlargement of portion of stele shown in figure 21. px, protoxlyem area.

Figure 23. *Asteroxylon Mackiei* Kidston and Lang. From a preparation in our collection by Hemingway. This is to be contrasted with figure 21 in regard to (1) form of stele, (2) position of protoxylem (px), (3) cellular organization of stele, (4) occurrence of leaf traces (lt) and (5) cortex, relatively narrow and uniform in *Stenokoleos*, broad and differentiated into well-defined zones in *Asteroxylon*.

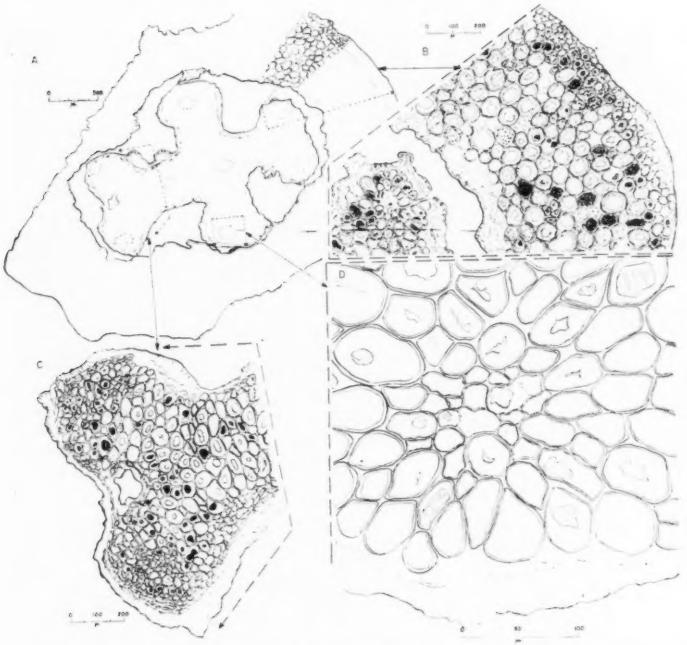


Figure 24 A-D. *Stenokoleos setchelli* (Read and Campbell) Hoskins and Cross. A camera lucida outline drawing indicating position of detailed drawings seen in B, C, and D. Dotted lines indicate positions of protoxylem in stele.

Figure 17. Transverse section illustrating a segment of the peripheral portion of the stem (*G. microphylla*) and two leaves. The three zones of the cortex, (ic, oc, and hy), are clearly defined. The leaf at the extreme upper left is one segment of the second order of bifurcation and it is comprised principally of sclerotic tissue, with a thin layer of mesophyll in crushed condition surrounding it. In the larger leaf the two vascular bundles (vb) are small and the mesophyll (m) areas are broad. A few sclerotic cells are developed near the lobe at scl. Cellular arrangement near the center of the leaf and the deep cleft at cl indicate early division of the leaf. (See cl2 in Fig. 15 for a comparable cleft at a slightly lower level before detachment of leaf).

Figure 18. A transverse section of a peripheral portion of the stem of *G. microphylla*. The main zone of cells comprise the hypodermis and the very small celled epidermis (e) is sharply demarcated. (See fig. 17 for approximate relationships).

Figure 19. Transverse section of portion of a leaf base (see fig. 20A for orientation) showing the development of the rather large-celled cortical tissue external to the position of the leaf trace (lt). Cortical (c) cells of smaller diameter (hy) are peripheral to this and lie just beneath the epidermis (e). The cells of the outer cortical area, c (see oc in Fig. 17) are gradational with the slightly sclerotized cells here and lie in a band just external to the leaf trace.

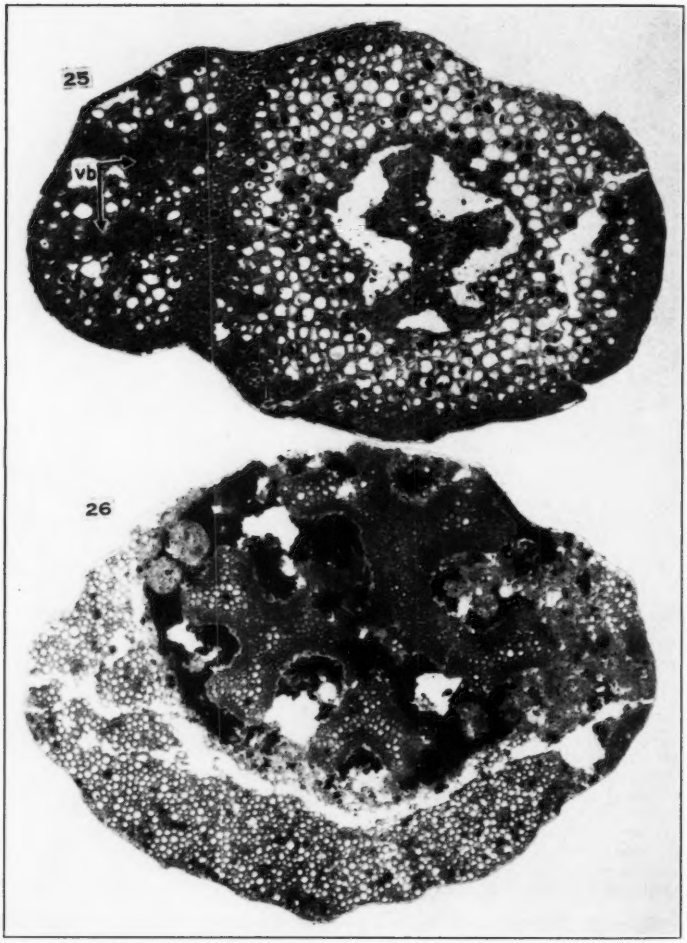


Figure 25. Preparation in collection of U. S. National Museum labelled "*Asteroxylon setchelli.*" This is possibly a second specimen of *Stenokoleos setchelli.* Note large attached leaf base at left with double vascular bundle (vb).

Figure 26. Preparation in U. S. National Museum labelled "*Asteroxylon setchelli.*" This is generically distinct from both *Asteroxylon* and *Stenokoleos.*

A New Pachytesta[1] From the Berryville Locality of Southeastern Illinois

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Recently several different kinds of petrified seeds belonging to the pteridosperms have been discovered in coal-ball material from the Berryville locality, Lawrence County, Illinois. The largest and most frequently found is *Rotodontiospermum illinoense* Arnold and Steidtmann (1937). Neely (1951) reported *Conostoma quadratum* Graham (1934) and a new genus *Coronostoma*, which like *Conostoma* is a small seed having its affinities with Lagenostomales. Genera of Trigonocarpales found at the locality, other than *Rotodontiospermum*, are *Stephanospermum* and *Pachytesta*. *Stephanospermum* is represented by a single specimen[2] and *Pachytesta* by four.[3] Three of the pachytestas are medium-sized (2.5-3.0 cm. long) one of which is well preserved; the fourth is small (about 1.0 cm. long) whose size and general aspect is similar to *Pachytesta pusilla*, (Brongniart) Hoskins and Cross (1946b).

Two petrified seeds showing structure and characters of the genus *Pachytesta* were reported in American coal-ball material by Krick (1932). The material was associated with No. 5 coal of the O'Gare Mine, Harrisburg, Illinois. Subsequently Reed (1939) described two seeds from the Allegheny series at Polks Patch near Boonville, Indiana and called them *Pachytesta gigantea* no. 1 and no. 2. These were later reinvestigated by Hoskins and Cross (1946b) and assigned to a new species, *P. noei*. *Pachytesta vera* was described by Hoskins and Cross (1946a) from the Des Moines series near Oskaloosa, Iowa. These five seeds represent the extent of described members of the genus *Pachytesta* in American petrifactions.

This paper deals with the description of a new species of *Pachytesta* from Berryville coal-ball material; effort is also made to relate it to other species of *Pachytesta* and to other genera of the Trigonocarpales as well.

Pachytesta hexangulata sp. nov.—This seed was found exposed on the weathered surface of a large coal-ball mass. The chalazal end and one side of the seed projected from the surface (fig. 4) so that these parts were eroded and partly lost. The seed was cut from the surrounding coal-bass mass and serial sections were made by the peel technic. Longitudinal sections were made from the surface of the seed to the point just beyond the median plane;

1 The genus *Pachytesta* as used in this paper follows the emendation of the *Trigonocarpus-Pachytesta* complex made by Hoskins and Cross (1946b).

2 This specimen was collected by Dr. J. W. Hall, Department of Botany, University of Minnesota.

3 Three of the four specimens are in the University of Illinois collection; the fourth was collected by Dr. J. W. Hall of the Department of Botany, University of Minnesota.

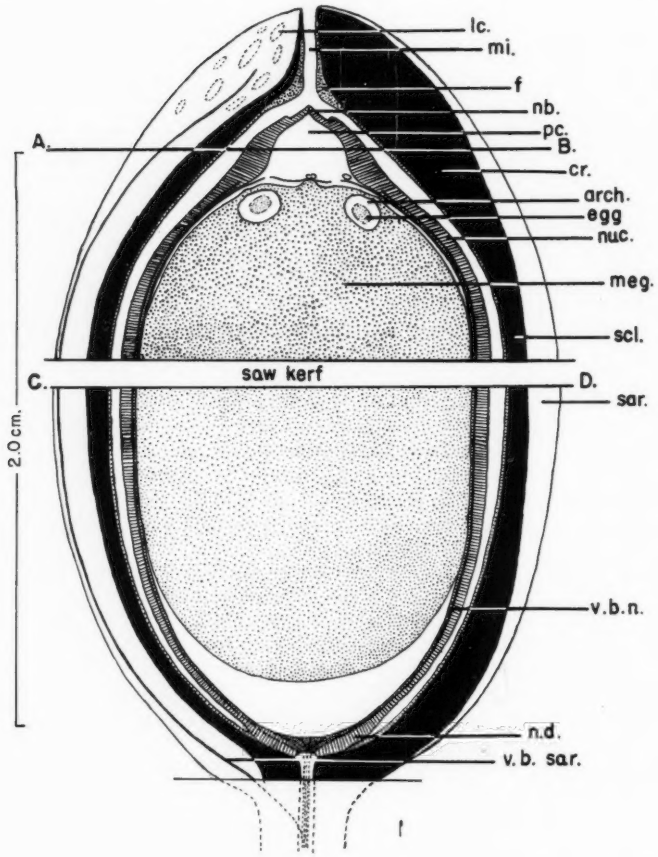


Fig. 1.—Median longitudinal section of holotype of *Pachytesta hexengulata* reconstructed from slides A 82 through A 111 of the Paleobotanical Collection, Department of Botany, University of Illinois.

Explanation of symbols: lc—lacunae, mi—micropyle, f—inner flesh, n.b. nucellar beak, p.c.—pollen chamber, c.r.—commissured rib, arch.—archegonium, nuc.—nucellus, meg.—megagametophyte, scl.—sclerotesta, sar.—sarcotesta, v.b.n.—vascular bundle of nucellus, n.d.—nucellar disk, v.b. sar.—vascular bundle of sarcotesta. Line A-B represents the level of the reconstructed cross section, figure 2; C-D the level of the reconstructed cross section, figure 3.

cross sections of the remaining part from which the reconstructions were made (figs. 2, 3) were taken at the levels indicated on figure 1. It was felt that such a reconstruction of an entire section from half a cross section was warranted since the seed showed characteristic radial symmetry prior to sectioning.

GENERAL CHARACTERS

The seed measures 2.6 cm. in length from the outer face of the basal nucellar disk to the outer opening of the micropyle at the apex of the seed, and 1.5 cm. in its maximum diameter when only the sclerotesta is included. The maximum diameter, including the sarcotesta, was probably in the vicinity of 1.75 cm., but because of the relatively poor preservation of this part of the integument this can be an approximation only. The seed is radially symmetric and slightly obovoid; the apical end is rounded and not extended into a long micropylar beak. The sarcotesta in the apical region of the seed is lacunar and invests a sclerotesta which in this same region shows three well developed commissured, radial extensions. Three secondary ribs are present alternating with the commissured ribs.

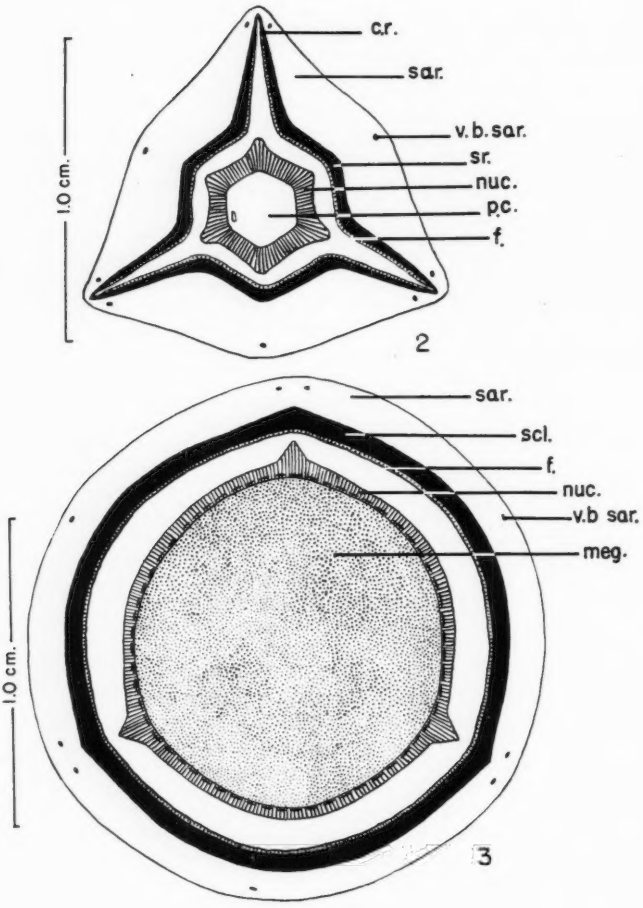
The nucellus occupies about seven-eighths of the length of the seed. It is free from the integument except at the base where it is attached by a broad cushion-like disk. Near its apex, the nucellus surrounds a conspicuous pollen chamber and in this region it is hexagonal in outline as seen in cross section.

Megagametophyte tissue fills about three-fourths of the area within the nucellus. At its apical end, three archegonia were found. Pollen grains of the *Monoletes* type are present in the pollen chamber and one of these shows microgametophyte tissue.

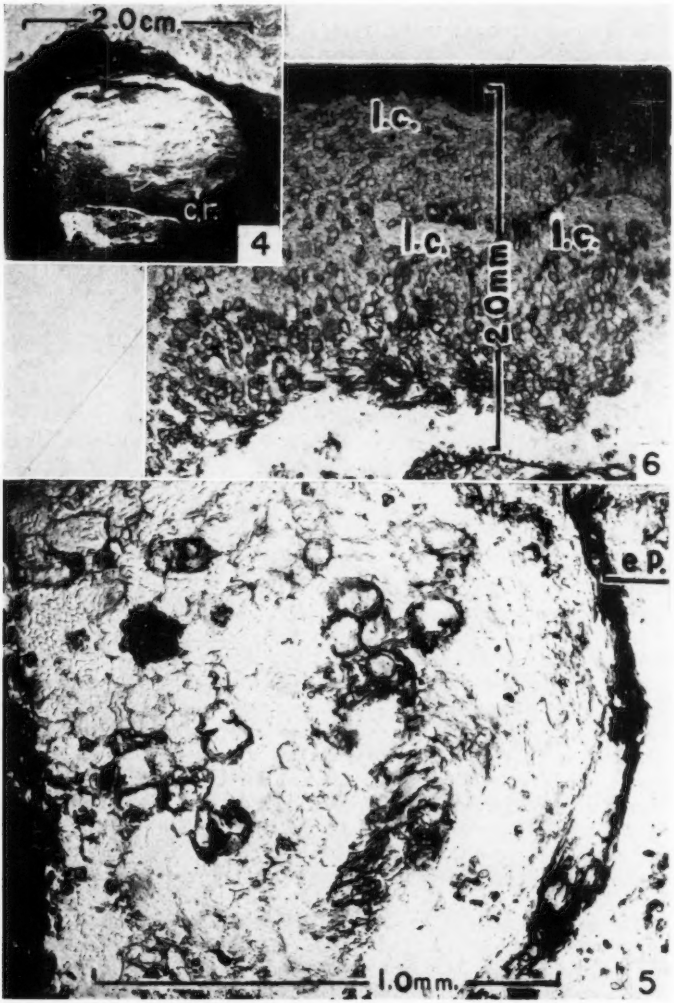
STRUCTURE OF SEED

Integument.—The integument, as in other species of *Pachytesta* (Hoskins and Cross, 1946a, 1946b) can be divided into three parts, the outer fleshy layer (sarcotesta), the stony layer (sclerotesta), and an inner fleshy layer which in this instance is apparent only in the area at the base of the micropyle. At its point of greatest thickness near the apex of the seed, the integument measures 2.6 mm. It decreases in thickness on the flanks so that in the area of greatest seed diameter, the integument is only about 1.3 mm. thick.

The sarcotesta is, for the most part, poorly preserved; however, in certain restricted regions it is more or less intact. In such a region near the apex of the seed and between the commissured ribs the sarcotesta reaches a maximum thickness of 2.0 mm. (fig. 1), while on the lower flanks of the seed it becomes thinner so that in the region of the middle one-third it is about 1.0 mm. thick. The sarcotesta did not form a layer of uniform thickness, being nearly twice as thick in the apical region as in the mid-region. It is bounded on its outer face by an epidermal layer (fig. 5). In a normal state the epidermal cells were probably small, thick-walled, and regularly arranged. Beneath this layer is an extensive area of loosely arranged, thin-walled parenchyma (figs. 5, 6, 7, 8) whose cells are smaller adjacent to the sclerotesta. Scattered among the thin-walled parenchyma are abundant groups of cells whose lumens are par-



Figs. 2, 3.—2. Cross section of holotype at level A-B, figure 1. Reconstructed from slide A 118 showing the hexagonal nucellus (nuc.) and the angulations of the sclerotesta forming the secondary ribs. (s.r.). 3. Cross section of holotype at level C-D, figure 1. Reconstructed from slide A 120 showing the three angulations of the sclerotesta (scl.) and the ribs of the nucellus (nuc.) opposite the angulations. (See figure 1 for explanation of symbols.)



Figs. 4-6.—4. The seed as it appeared prior to sectioning, showing the position of a commissured rib (c.r.), and the depression at the chalazal end of the seed. Coal ball. 710. 5. Sarcotesta with poorly preserved epidermis (ep) covering the broad parenchymatous layer. Slide A 96. 6. The sacrotesta of the apical region of the seed showing the distribution of lacunae (lc). Slide A 97.

tially filled with opaque materials (figs. 5, 6, 7, 8) suggesting that these cells were secretory in function. No resin canals were found in any part of the integument. The inner margin of the sarcotesta is delimited by a thin zone of small, epidermal-like cells. These, like other cells of the sarcotesta, are thin-walled, but differ in that their lumens are completely filled with opaque materials (fig. 7).

The expanded portion of the sarcotesta in the apical region of the seed is lacunose (fig. 6). It seems unlikely that these lacunae represent the former position of vascular traces in the sarcotesta in view of their abundance and irregular distribution. The lacunose condition of the sarcotesta is well developed in *Aetheotesta* as described by Brongniart (1874a, 1874b, 1881) and Renault (1896) which in this respect is quite similar to *Pachytesta hexangulata*.

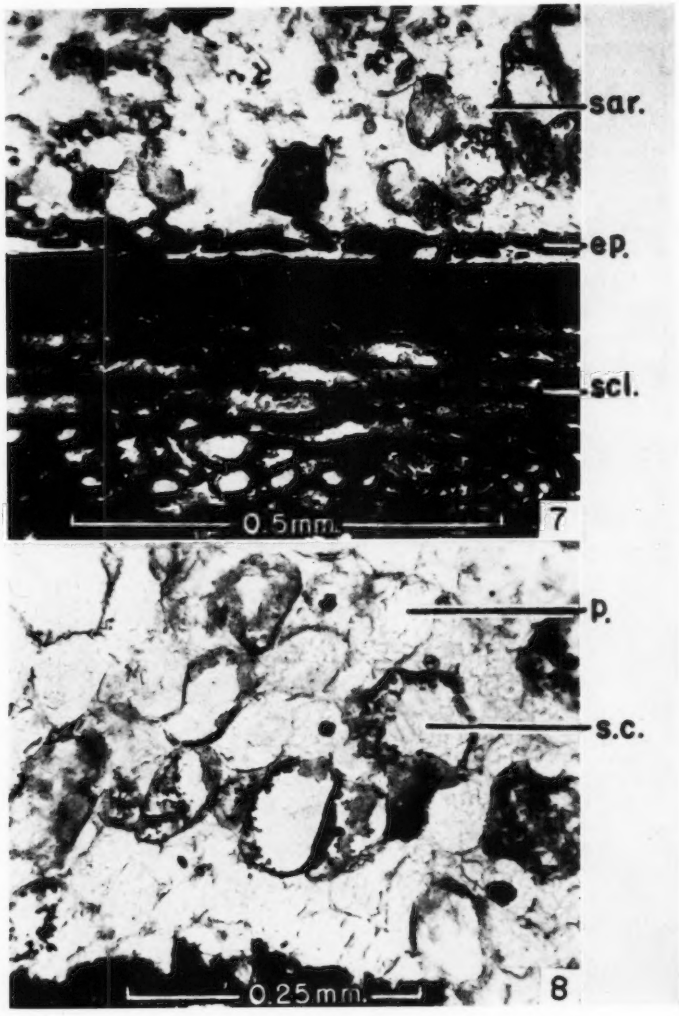
The sclerotesta (fig. 1) varies in thickness even in the areas extending between the commissured ribs, where, slightly above the mid-region of the seed, it is 0.50 mm. thick, decreasing in thickness above in the region of the micropyle and below on the lower flanks of the seed. Two zones can be distinguished. (1) An outer zone about 0.12 mm. thick consists of slender, fibrous, radially arranged, cells (fig. 9) which because of their orientation present a palisade-like appearance. This configuration is suggestive of the genera *Aetheotesta* (Brongniart, 1874a and Renault, 1896), *Stephanospermum* (Brongniart, 1881), and *Sarcospermum* (Deevers, 1937) where cells of the sclerotesta show a similar arrangement. (2) To the inside of the palisade-like layer there is a relatively broad zone, 0.3 mm. thick, consisting of sinuous, intertwined cells (fig. 9).

Near the apex of the seed, the sclerotesta is extended into three, radially arranged, commissured ribs (figs. 1, 2, 11). At the mid-point of the seed these ribs are so reduced that they are only slightly thickened and angulated regions of the sarcotesta (fig. 3). In the basal one-third of the seed, these three major ribs appear again as radial extensions of the sclerotesta (figs. 1, 12). Between the commissured ribs in the vicinity of the seed apex, the sclerotesta is sharply angulate, the point of angulation being about midway between the adjacent commissured ribs. There are three such angles alternating with the three commissured ribs (figs. 2, 10) which are probably homologous with the more prominent secondary ribs of the other species of *Pachytesta*. These secondary ribs (angulations) persist for the upper one-third of the seed.

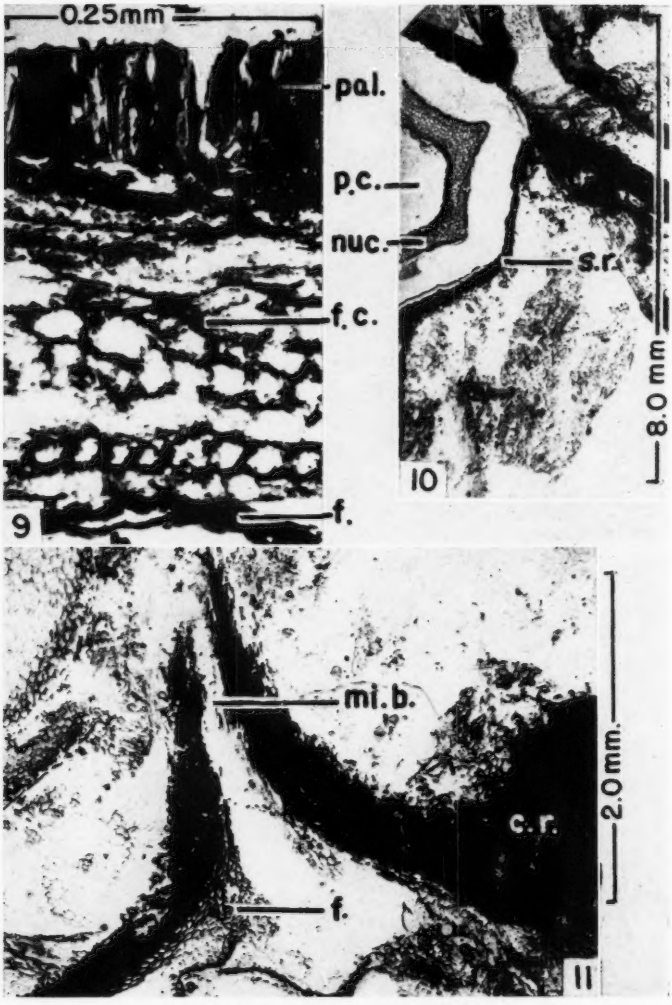
The integument at the distal end of the seed is rounded off so that only a short micropylar beak is formed (figs. 1, 11). The centrally located micropyle is about 4.0 mm. in length and 0.5 mm. in width. It is lined by the inner fleshy layer of the integument.

The inner fleshy layer is fairly well developed at the base of and in the lining of the micropyle (figs. 1, 11, 13). Elsewhere it is reduced to a single layer of small, cutinized, epidermal cells (fig. 9) whose lumens are completely filled with opaque materials.

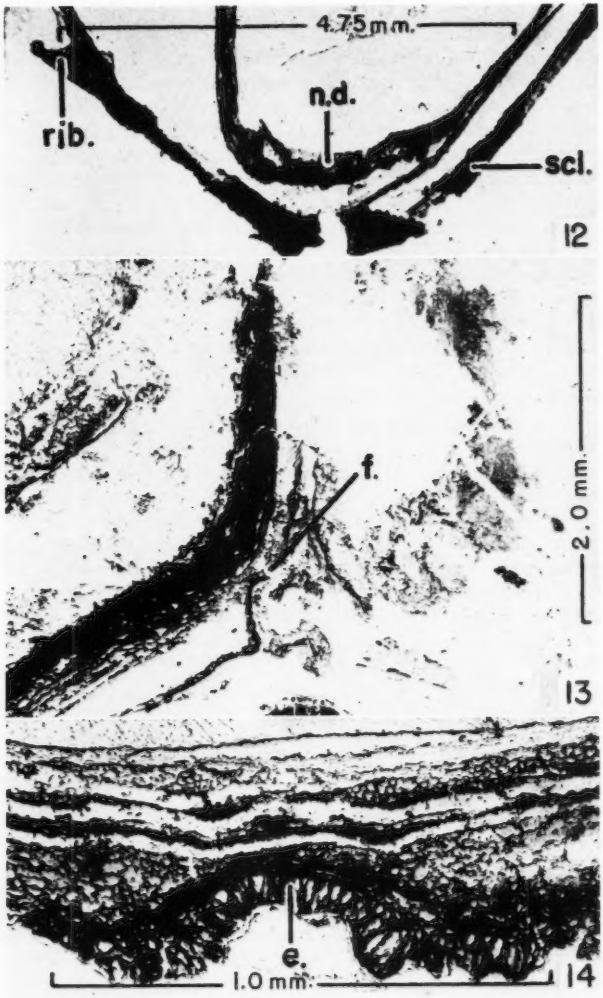
Nucellus.—The nucellus extends through about seven-eighths of the total



Figs. 7, 8.—7. The integument showing the relationship of sarcotesta (sar.) to the sclerotesta (scl.), and the epidermal-like cells (ep.) at the inner margin of the sarcotesta. Slide A 115. 8. Secretory cells (s.c.) and thin walled parenchyma (P.) of the sarcotesta. Slide A 64.



Figs. 9-11.—9. Sclerotesta showing the two layers, the outer palisade-like cells (pal.) and the inner fibrous cells (f.c.). The epidermal cells in inner fleshy layer (f) show the slightly separated cuticle. Slide A 107. 10. Cross section through the level of pollen chamber (p.c.), showing angulate nucellus (nuc.), angulation of sclerotesta, i.e., a secondary rib (s.r.). Slide A. 118. 11. Longitudinal section through micropylar beak (mi.b.) with expanded inner flesh (f.) and commissured rib (c.r.). Slide A 111.



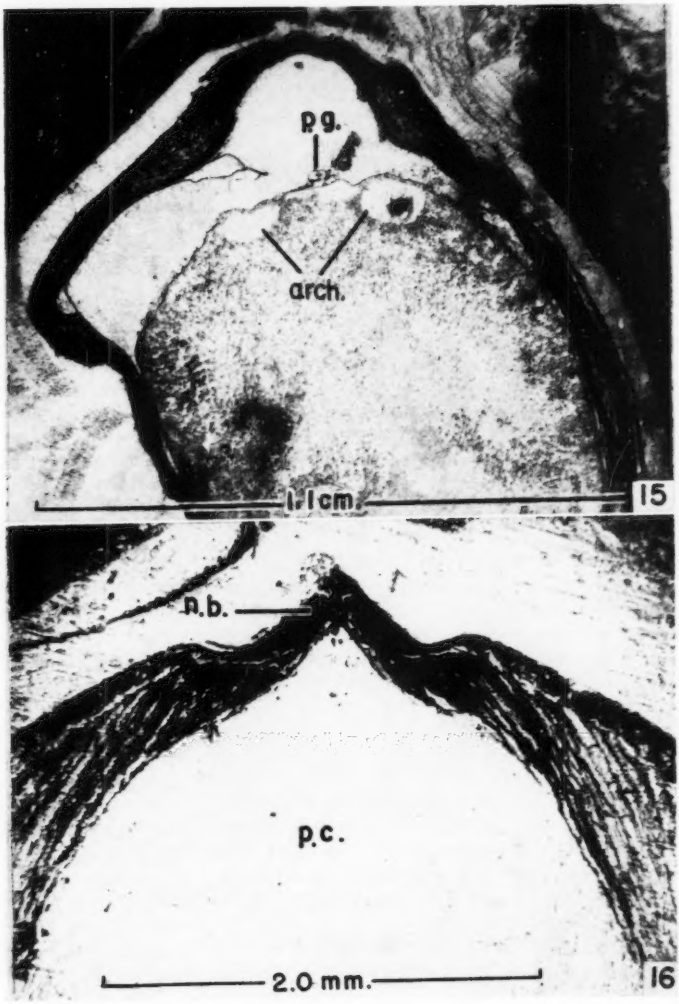
Figs. 12-14.—12.—Slightly oblique longitudinal section at base of seed including nucellar disk (n.d.), the sclerotesta (scl.) and one of the three major ribs (rib). Slide A 82. 13. Longitudinal section in region of micropyle with epidermis (f) of inner flesh extended into the micropylar beak. Slide A 107. 14. Nucellar disk at point of the depression which is lined with palisade-like epidermal cells (e). Slide A 92.

length of the seed (fig. 1). It is free from the surrounding integument except at the chalazal end. Figure 12, an oblique section through the chalazal end of the seed, shows the nucellus separated from the integument. This is no doubt the result of faulty preservation. None of the serial sections through the base of the seed shows any indication of a nucellar stalk. The configuration of the nucellus in the basal position is that of a broad, cushion-like, sessile disk (figs. 1, 12, 14) fused in its lateral extent with the integument. At the center of the disk, on its outer face, there is a marked depression (fig. 14) which marks the point of entrance of the vascular supply into the nucellus. This depression was apparent on the exposed surface of the seed prior to sectioning (fig. 4). The nucellar disk is approximately 1.6 mm. in diameter and 0.75 mm. in maximum thickness. At the margins of the disk the nucellus thins, gradually becoming thicker above so that in the middle one-third of the seed it is 0.3 mm. thick. At the base of the pollen chamber (figs. 1, 2, 10, 15) the nucellus thickens abruptly to 0.85 mm. decreasing again in thickness to 0.15 mm. in the region of the nucellar beak (figs. 1, 16).

Three types of cells occur in the nucellus except where it forms the walls of the pollen chamber. An epidermis covers its outer surface; on its flanks the epidermis is composed of large isodiametric cells (figs. 17, 18) measuring 0.10 mm. In the regions of the nucellar beak (fig. 16) and the depression in the nucellar disk (fig. 14) the epidermal cells are radially elongate having radial measurements of 0.13-0.15 mm. and are palisade-like in appearance. The walls of the epidermis are thick, the outer tangential walls being covered by a heavy cuticle which is frequently found detached from the epidermal surface. The bulk of the nucellus, to the inside of the epidermis, consists of thin-walled parenchyma (figs. 14, 17, 18, 21), and the vascular supply of the nucellus is found embedded near the inner margin of this parenchymatous layer.

The pollen chamber is a dome-shaped cavity (figs. 1, 15, 16), situated directly above the upper limits of the ruptured megaspore membrane. In the median section the pollen chamber is 2.3 mm. in height and 3.0 mm. across the base. At the level of the pollen chamber, seen in cross section, the nucellus is hexagonal in outline (figs. 2, 10). Three of the six angles are prominent and each is opposite one of the three commissured ribs. These three major nucellar ribs decrease in extent from the level of the pollen chamber towards the base of the seed so that they appear as pointed extensions of the nucellus (figs. 3, 18) at the mid-region of the seed. Alternating with the major nucellar ribs, at the level of the pollen chamber, there are three minor ribs (figs. 2, 10) which lie opposite the angled secondary ribs of the sclerotesta. The minor nucellar ribs are present only in the upper one-third of the seed.

The nucellar beak lies at the apex of the pollen chamber where it forms an inverted funnel in the center of a shallow depression (fig. 16). The longitudinal median section through the nucellar beak (fig. 16) shows it to be closed with a poorly defined suture indicating the line of closure. The most conspicuous cells of the nucellar beak are the palisade-like epidermal cells



Figs. 15, 16.—15. Longitudinal section, near median, of upper one-half of seed. Note relationship of pollen grain (p.g.) to the archegonia (arch). Slide A 105. 16. Median longitudinal section of the pollen chamber (p.c.) and the closed nucellar beak (n.b.). Slide A 110.

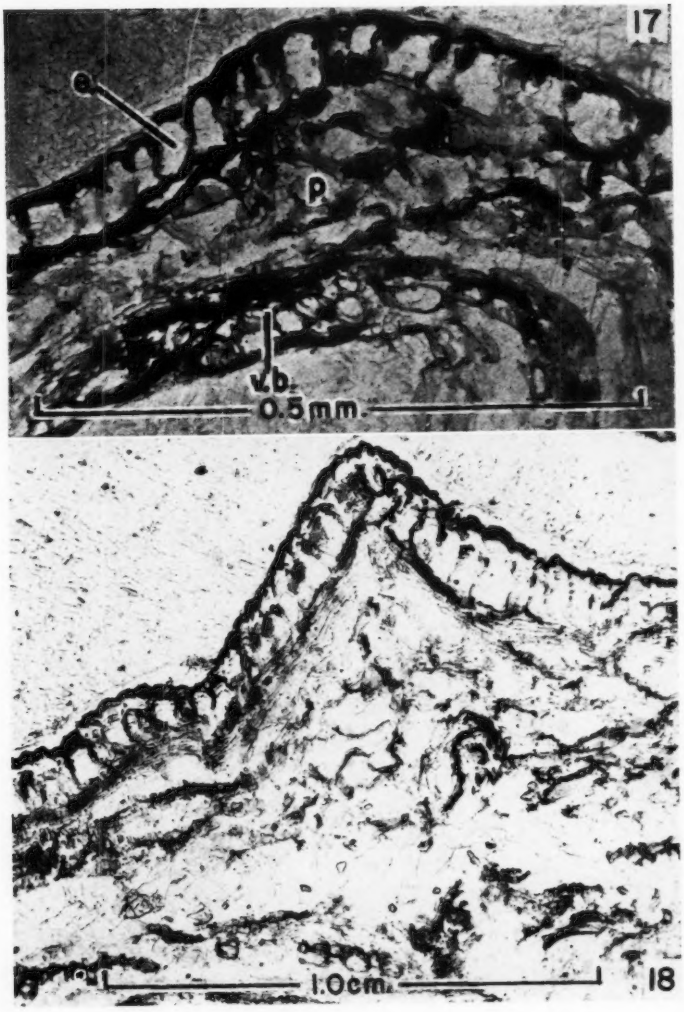
(0.15 mm. in radial extent) whose lumens are completely filled with opaque materials. On the flanks of the beak the epidermal cells decrease rapidly in size so that in the region of the depression they are very small (fig. 16), measuring 0.05 mm. A single layer of vertically elongated parenchyma cells invests the inner face of the nucellar beak epidermis. In its downward and outward extent this layer increases rapidly in thickness so that directly beneath the apical depression the parenchymaotus layer is about 4-6 cells thick; it continues to increase in thickness to the level of the base of the pollen chamber (figs. 1, 15, 16) where it again gradually decreases in the flanks of the seed. The parenchyma cells of the nucellus bounding the pollen chamber are elongate increasing in length as the nucellar beak is approached (fig. 16). In this position, their cell cavities are filled with an opaque (figs. 16, 19) material similar in appearance to that of the nucellar beak cells.

The structure and arrangement of the nucellar beak and its subtending cells suggest that there was present in these seeds a post-pollination growth mechanism causing the closure of the aperture into the pollen chamber. This interpretation seems plausible in view of the presence of spores, all of the monolete type (Schopf, 1938, Schopf, Wilson and Rentall, 1944) in a pollen chamber which was completely intact and whose nucellar beak was in a closed position at the time of preservation. It is noteworthy that a similar post-pollination stage has been figured by Brongniart (1881) (cf. pl. 14—figs. 2, 3, 5, 8) for *Stephanospermum akenioides*, also a member of the Trigonocarpales.

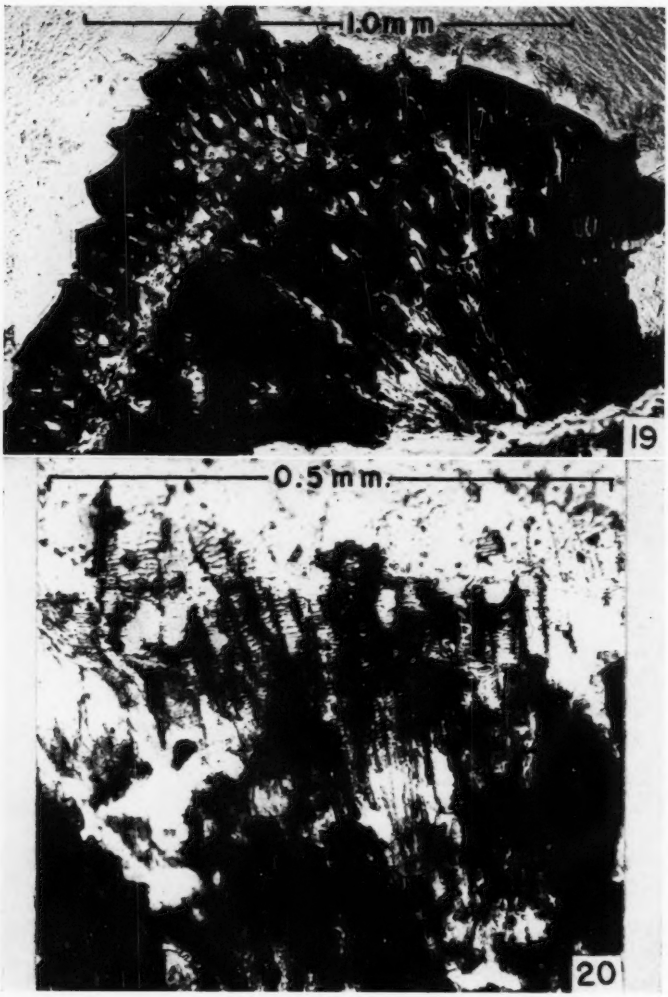
Vascular System.—Like other members of the genus *Pachytesta*, *P. hexangulata* possesses a double vascular system, that of the sarcotesta of the integument, and of the nucellus. Because of the poor preservation at the base of the seed, the first evidence of vascularization is in the nucellar disk. Here, a single vascular strand enters from below (fig. 20), radiating in the upper part of the disk to give rise to the discrete vascular bundles of the free nucellus (figs. 3, 14, 17, 18). In the mid-region of the seed there are approximately 35 such bundles which in some cases lie so close to one another that they are confluent in their lateral extent. The vascular bundles of the nucellus terminate at the level of the pollen chamber base.

Tracheids of the nucellar vascular bundles are of two types; large tracheids, probably metaxylem, whose walls show thickenings chiefly of the reticulate type (fig. 21), and small tracheids, presumably protoxylem, with spiral thickenings. Both cross and longitudinal sections show the smaller elements surrounded by the larger ones, giving a mesarch aspect to the vascular bundles of the nucellus.

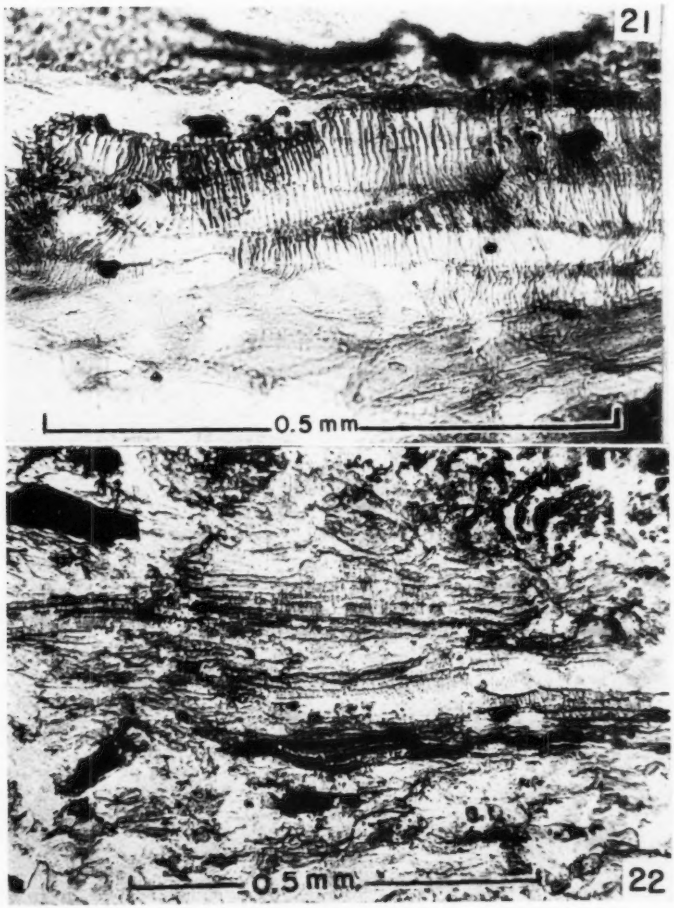
The description of the vascularization of the sarcotesta is limited because of poor preservation and the absence of the portion of the seed below the chalazal disk. The remains of several vascular bundles were found in the outer one-third of the sarcotesta (fig. 22). Near the apex of the seed a vascular bundle was found adjacent to a commissured rib; another was found well toward the outer margin of the sarcotesta at a point mid-way between the major rib. The positions of these are indicated in figures 1, 2, and 3. Judg-



Figs. 17, 18.—17. Cross section of nucellus showing the cutinized epidermis (e.), the thin walled parenchyma (p.) and one of the vascular bundles (v.b.). Slide A 120. 18. Cross section of nucellus near the mid-point of the seed showing one of the three nucellar ribs. Slide A 120.



Figs. 19, 20.—19. Cross section through the nucellar beak. Slide A 116.
20. Vascular tissue of the nucellar disk. Slide A 82.



Figs. 21, 22.—21. Longitudinal section of vascular bundle of nucellus. Slide A 82.
22. Longitudinal sections of vascular bundle in the sarcotesta. Slide A 93.

ing from the number of fragments of vascular bundles associated with the fragmentary sarcotesta, there were many more of these than indicated in the reconstructions of the cross sections (figs. 2, 3). The point of connection between the main vascular supply at the base of the seed and that of the sarcotesta was lost. It is apparent, however, that this connection was at a point below the lower limits of the sclerotesta and this is indicated by the absence of any vascular tissue within or above the sclerotesta except that of the nucellus. Tracheids of the vascular bundles of the sarcotesta are similar in structure to those described for the nucellus.

Prepollen.—Serial longitudinal sections through a little over one-half of the pollen chamber showed four spores (figs. 23, 26, 27, 29), all of the same type. They appear to be identical with those described by Schopf (1938) and Schopf, Wilson and Rentall (1944) as the prepollen type, *Monoletes*. Serial sections through two of the spores (figs. 23, 24, 27), made parallel to their long axes, show the following characters of the genus; spores bilaterally symmetric, monolete suture present, elliptical in outline, relatively large in size (365μ in length), and surface minutely granulose (fig. 24). Monolete spores were removed from the sporangia of a *Codonotheca* fructification and compared with those found in the pollen chamber of *P. hexangulata*. The most important point of similarity is in the absence of distal grooves and umbo for both spore types. Figure 24 shows the distal face of a sectioned spore with no indication of the grooves and umbo described for *Monoletes* by Schopf (1949) and Schopf, Wilson and Rentall (1944). The spore illustrated by figure 26 seems to exhibit a single distal and proximal groove; however, this configuration is probably due to the partial collapse of the exospore, a condition which is very pronounced in the spore illustrated by figure 27. Spores of *Codonotheca* measure about 340μ in length; those associated with *P. hexangulata* are a little larger having an average length of 365μ. The maximum length for both, however, was 378μ. Of the monolete spore types thus far described, those of *Codonotheca* most closely approximate the prepollen found in the pollen chamber of *P. hexangulata*.

The question still remains whether or not the monolete prepollen described above and the seed *P. hexangulata* are conspecific. The bulk of evidence indicates that the two belong to genetically similar plants.

1. The pollen chamber is intact, not allowing contamination by foreign spore types due to faulty preservation.

2. All spores are of the same (monolete) type. A similar situation is reported by Hoskins and Cross (1946a) for *Pachytesta vera*, but here the spores are of the *Florinites* type. Such evidence is important but not conclusive in itself.

3. One and possibly two of the prepollen grains show the remains of microgametophyte tissue (figs. 23, 25, 26). Again, this evidence is not conclusive, but at least the presence of developing prepollen increases the probability of the seed and prepollen being conspecific. In modern gymnosperms, as described by Coulter and Chamberlain (1910) and Chamberlain (1935), the early stages of microgametophyte development occur prior to pollination

Figs. 23-26.—23. Monolete spore with two cells of the microgametophyte. Slide A 111. 24. Distal surface of monolete spore shown in figure 23. Note the absence of groves or umbo. Slide A 115. 25. Two cells of microgametophyte shown in figure 23 at a greater magnification. Slide A 111. 26. Longitudinal section of monolete spore showing exospore (ex.), endospore (en.) and what appears to be the remains of microgametophyte tissue. Slide A 105.

so that the prepollen described above could still be from a plant unrelated to the seed and at the same time show microgametophyte tissue.

4. All four prepollen grains were found on the floor of the pollen chamber in close proximity to the archegonia. This feature may be of importance in establishing the conspecific nature of the seed and associated prepollen. In certain modern gymnosperms the position of development and number of mature archegonia in the megagametophyte is determined by the proximity of pollen tubes and sperms formed by conspecific pollen. In *Microcycas calocoma*, Caldwell (1907) reported the presence of a large number of sperm cells in the pollen tubes and a proportionately large number of archegonia. Buchholz (1939) found that the pollen tubes of *Sequoiadendron gigantea* make their way to the sides of the megagametophyte and it is in this lateral position that archegonial initials appear adjacent to the pollen tubes. The general tendency among gymnosperms for the position of archegonia to be determined by the position of pollen tubes was recognized by Coulter and Chamberlain (1910) p. 241. They state,

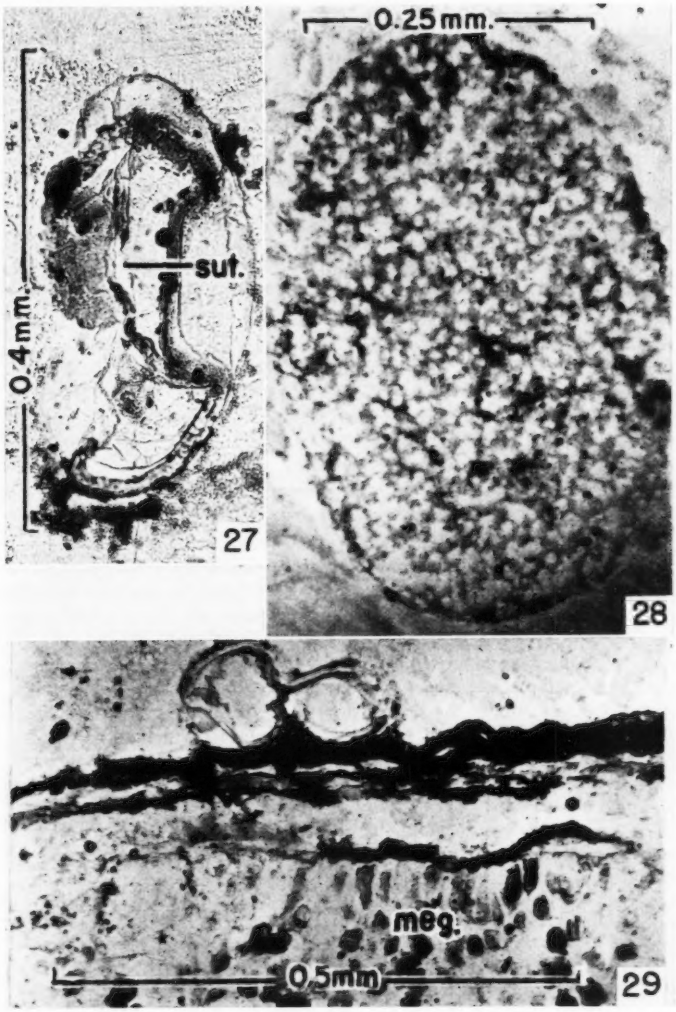
> "It is becoming evident that the position of archegonia (in gymnosperms) is related to the position of the pollen tube, which sometimes reaches the embryo sac before archegonium initials are selected. In cases where the pollen tube assumes a lateral position (*Sequoia* and *Widdringtonia*), it has been demonstrated that the latter responds by the selection of numerous deep-seated and laterally placed archegonium initials. It may be inferred, therefore, that the usual micropylar position of archegonia is due to the usual micropylar position of the tip of the pollen tube."

If Coulter and Chamberlain's generalization for modern gymnosperms is applicable to fossil forms then it appears that the prepollen found in the pollen chamber of *P. hexangulata* is conspecific with this seed, for archegonia are developed in close proximity to the prepollen grains.

5. In *Pachytesta hexangulata* the nucellar beak is closed and the nucellus of the pollen chamber is much thicker than the same structure in other species of *Pachytesta* described by Scott and Maslen (1907), Sailsbury (1914) and Hoskins and Cross (1946a). These growth changes may indicate post-pollination stages initiated by the presence of conspecific pollen. By comparison, it should be noted that in modern gymnosperms growth of the ovule is normally a post-pollination phenomenon, involving the rapid growth of the megagametophyte, growth of the nucellus especially at the apical end, and closure of the micropyle by growth of the integuments.

The foregoing evidence indicates as conclusively as it seems possible, in the case of a fossil, that a monolete type of prepollen similar to that of *Codonotheca* is conspecific with this species of *Pachytesta*. Monolete prepollen has long been suspected as being the microspore type for certain of the Trigonocarpales (Schopf, 1938, 1949, Schopf, Wilson and Rentall, 1944) and these findings help to strengthen the hitherto supposed relationship between this order and the sub-tribe Whittleseyinae.

Gametophytes.—Both micro- and megagametophytes are present in *Pachytesta hexangulata*. The microgametophyte (figs. 23, 25) is a two-celled structure still enclosed within the spore membranes of one of the four prepol-



Figs. 27-29.—27. Longitudinal section parallel to the proximal face of a monolete spore with monolete suture (sut.). Slide A 103. 28. The cytoplasm of an egg. Slide A. 109. 29. The megagametophyte (meg.) in the region of the "tent pole" and a monolete spore resting on the "floor" of the pollen chamber. Slide A 111.

len grains in the pollen chamber. The stage of microgametophyte development represented here is conjectural; however, there is a striking resemblance in the orientation and appearance of these two cells to the sperms of modern cycads, as illustrated by Coulter and Chamberlain (1910) and Chamberlain (1935). Buchholz[4] has observed that supernumerary sperm cells of *Zamia* may persist at the apex of an archegonium for nearly three months after fertilization. If these cells of the extinct plants showed the same persistence it is conceivable that they were preserved. The larger of the two cells shown in figure 25 is 65 x 85μ and is comparable in size to the sperm cells of *Microcycas*, but considerably smaller than those of other cycads. If similarity of structure and appearance can be considered as valid evidence, then the two cells (fig. 25) are conceivably sperm cells. Benson (1908) has described structures of similar size and appearance in the pollen chamber of *Lagenostoma ovoides*. Here, three of the supposed sperms are free in the pollen chamber with no indication of pollen tubes being present. A search for pollen tubes in the vicinity of the archegonia of *Pachytesta hexangulata* failed to reveal their presence. Although such negative evidence is not conclusive, it serves to substantiate the assumption that none was present in members of the pteridosperm complex where the prepollen grains come to lie next to the ruptured megaspore membrane and thus are practically on top of the exposed necks of the archegonia of the megagametophyte. It would be indeed surprising to find pollen tube-like growths bridging this short distance especially if motile sperms were present.

The megagametophyte of *Pachytesta hexangulata* in its pertrified state occupies the upper three-quarters of the space within the nucellus (figs. 1, 3, 15). Megagametophyte tissue showing preservation of cellular detail is found in the region of the slightly raised, apical "tent-pole" (figs. 1, 29) and in the vicinity of the archegonia (figs. 1, 15). During the sectioning of the megagametophyte three archegonia were encountered at the apex of the megagametophyte and around the centrally located "tent-pole." Each archegonium contained a large cytoplasm mass (fig. 28) which could hardly be anything but an egg in a pre- or post-fertilization stage. The egg-containing cavity is large (0.7 x 1.2 mm.) and readily visible macroscopically. The egg, which partially fills the archegonial cavity is elliptical in outline, measuring 345 x 525μ. The carbonized cytoplasm of the egg is in the form of a network whose members are separated by large alveoli, the whole structure being bounded by a very delicate membrane. Many archegonia have been figured and described by Brongniart (1881) and Neely (1951) for Palaeozoic seed genera, but this is the first report of their occurrence in the genus *Pachytesta*.

DIAGNOSIS

Pachytesta hexangulata sp. nov.—Seeds approximately 2.7 cm. in length and 1.7 cm. in diameter; radially symmetric and obovoid; integument rounded at apex to form a short micropylar beak; three commissured ribs

[4] Personal communication to the author.

present which are much reduced in the middle one-third of the seed; three secondary ribs alternating with the commissured ribs, the secondary ribs represented by angulations in the sclerotesta of the upper one-third of the seed; sclerotesta characterized by a peripheral, palisade-like layer of cells; sarcotesta with many secretory cells, and with lacunae present in apical portion; inner fleshy layer much reduced except at the base of the micropyle.

Horizon.—McLeansboro group, Pennsylvanian system, Illinois.

Type.—Slide A. 110 Paleobotanical Collection, Department of Botany, University of Illinois. Figure 1 of this paper.

DISCUSSION

Sarcospermum ovale Deevers (1937) more closely approximates the size and structure of *P. hexangulata* than any other seed of the Trigonocarpales, in spite of the fact that commissured ribs are apparently lacking in *Sarcospermum*. A summary of the characters for the two seeds is presented below.

The seed described by Deevers (1937) is not well preserved, and for this reason other characters which might be compared with *P. hexangulata* are not available. Hoskins and Cross (1946b) have made a preliminary comparison between *Sarcospermum* and *Aetheotesta* and they conclude:

". . . the genus *Sarcospermum* (which) appears from a preliminary examination to be practically indistinguishable from *Aetheotesta*."

It is apparent that these authors consider the genus *Sarcospermum* sufficiently similar to the genus *Aetheotesta* to be included with it. There are some points of difference, however, between the genus *Atheotesta* as described (1874a) and figured (1874b) by Brongniart and the genus *Sarcospermum* Deevers (1937).

Brongniart describes the sclerotesta of *Aetheotesta* in the following way, ". . . à testa epais homogéne, formé de fibres ou cellules allongées dirigées perpendiculairement à la surface; . . ." The sclerotesta of *Sarcospermum* is heterogeneous being composed of two layers, an outer palisade-like layer of fibrous cells and an equally thick inner layer of elongated, sinuous, fiber-like cells. Although Deevers mentions that a crushed sarcotesta is present, nothing is indicated as to its structure. According to Brongniart's description of *Aetheotesta*, the lacunae and elongated cells of the sarcotesta in the basal and apical regions of the seed are important generic characters. *Pachytesta hexangulata* is similar to *Aethotesta subglosbosa* (Brongniart, 1874a) and *A. elliptica* (Renault, 1896) in size and in the lacunose nature of the sarcotesta in the apical region of the seed, but even in this respect the two differ in the number and arrangement of the lacunae; the cells composing the sarcotesta in this region also differ. The genus *Aetheotesta* is further characterized by its extended micropylar beak, a feature lacking for *Sarcospermum ovale* and *P. hexangulata*.

Of the two genera, *Aetheotesta* and *Sarcospermum*, *P. hexangulata* stands closest to the latter and shows a combination of features which unite the two genera, i.e., having the shape, size and the structure of the sclerotesta of *Sarco-*

Seed	Symmetry	Shape	Size	Integument	Ribs	Micropylar end of seed	Nucellus
Sarcospermum ovale	radial	ovoid (crushed)	3.0 x 1.5	1. 3 parts a. Sarcotesta (crushed) b. Sclerotesta with outer palisade layer 0.5 mm. in extent. Inner layer of elongated fibrous cells 0.5 mm. thick c. Inner fleshy layer reduced or absent.	absent	Sclerotesta slightly pointed. No long micropylar beak.	20 (?) vascular strands not fused except at base. 35-40
Pachytesta hexangulata	radial	slightly obovoid	2.6 x 1.7	1. 3 parts a. Sarcotesta lacunose near seed apex. b. Sclerotesta with outer palisade layer 0.2 mm. in extent. Inner layer of elongated fibrous cells 0.3 mm. thick. c. Inner fleshy layer reduced to a single row of epidermal cells except at the micropyle.	present	Sclerotesta sharply pointed in areas between commissured ribs. No long micropylar beak.	35-40 vascular strands showing some fusion other than at the base.

spermum, and the commissured ribs of *Pachytesta*. Thus it is proposed to extend the genus *Pachytesta*, to include the genus *Sarcospermum*.

PACHYTESTA (Brongniart) Stewart, emend.

1874 *Pachytesta* Brongniart in Compt. Rend. Paris 79 (7): 430-431. 1937 *Sarcospermum* Deevers in Bot. Gaz. 98: 580. 1946 *Pachytesta* (Brongniart) Hoskins and Cross in Amer. Midl. Nat. 36 (1): 207-251.

The characters for the genus *Pachytesta*, as emended, are the same as those given by Hoskins and Cross (1946b) except for the following additions:

1. Nucellus stalked or sesile.

2. Longitudinal, commissured, radial extensions of sclerotesta and non-commissured secondary ribs present or absent; if absent the sclerotesta is smooth at its surface for the full extent of the seed having no ornamentation of any kind and is heterogeneous, being composed of an outer layer of fibrous palisade-like cells and an inner layer of elongate, sinuous, fibrous cells.

The generic characters for the sclerotesta given above serve for the present to exclude the genera *Stepanospermum* and *Aetheotesta* although additional evidence may necessitate further expansion of the genus *Pachytesta* to include either one or both of them.

Pachytesta ovale (Deevers) Stewart comb. nov.

1937 *Sarcospermum ovale* Deevers in Bot. Gaz. 98: 580-584, figs. 27-36.

Seeds approximately 3 cm. long and 1.5 cm. in diameter; ovoid; circular in cross section; sarcotesta present; sclerotesta of two layers, an outer layer of palisade-like cells 0.5 mm. thick, an inner layer of elongated, fibrous cells 0.5 mm. thick; no ribs or sutures; sclerotesta slightly pointed at micropyle and enlarged at basal end; no extension of micropylar beak; nucellus free to base showing 20 (?) vascular strands in cross section.

Horizon and locality.—Carbondale group above No. 2 coal, Wilmington, Illinois.

Holotype.—Specimen figured by Deevers (1937), figs. 27-36. Paleobotanical Collection, Department of Botany, University of Chicago.

The author does not feel that the presence or absence of commissured ribs, when used as a character by itself, is of great enough importance to warrant distinction among seeds at the generic level. The evidence for this assumption is found in the variability in the degree of development of commissured and secondary ribs for species of *Pachytesta*. For example, cross sections of the seed *P. olivaeformis* (Williamson) Hoskins and Cross (1946b) show three conspicuous commissured and nine secondary ribs. Similar sections for *P. shorensis* Sailsbury (1914) and *P. vera* Hoskins and Cross (1946a) show the commissured ribs much reduced in extent and three secondary ribs present only in the apical region of the seed. The commissured ribs of *P. hexangulata* at the mid-point of the seed are so reduced in extent that they are represented by slight angulations in the sclerotesta and the same

row of epidermal cells except at the micropyle.

is true for the secondary ribs in the apical region of the seed. In *P. pusilla* (Brongniart 1881) the commissured ribs are represented by angulations of sclerotesta, secondary ribs are lacking. It seems that there is a tendency, within certain members of the genus *Pachytesta* either towards reduction or elaboration of the ribs of the sclerotesta with *P. ovale* representing the most advanced or the most primitive type depending on how the series is interpreted. From the standpoint of stratigraphy, the author is inclined to favor the interpretation that the series is one of reduction with *P. ovale* among the more advanced members. Pachytestas described from the Lower Coal Measures of the lower Upper Carboniferous of England (Williamson, 1877; Scott and Maslen, 1907; Sailsbury, 1914) are medium to large in size with extended micropylar beaks, having commissured and secondary ribs. Higher in the Upper Carboniferous of Europe (Stephanian) and the Pennsylvanian of North America there appears to be greater diversity within the genus. Brongniart (1881) illustrates *P. incrassata, P. gigantea* and *P. pusilla* from the Stephanian (Grand' Croix). Hoskins and Cross (1946a, 1946b) describe *P. vera* from the Des Moines Series and *P. noei* from the Allegheny Series, both series belonging to the Pennsylvanian System of North America and well above the Lower Coal Measures. *P. incrassata* and *P. gigantea* are among the largest (9-11 cm. long) of the genus, while *P. pusilla* is the smallest species (6.5 mm. long) thus far assigned to the genus. These diversified seeds from the middle and upper part of the Upper Carboniferous seem to fall into one of two groups each of which may represent an evolutionary line within the genus. One line is represented by species with large to very large seeds, well developed ribs, extended micropylar beak, and nucellus with a conspicuous stalk. *P. incrassata, P. gigantea, P. vera,* and probably *P. noei* would be included in this group. The second line is one marked by reduction and retention of characters. This is especially evident when comparison is made between those seeds high in the Upper Carboniferous and those of the Lower Coal Measures. Seeds belonging to the second evolutionary line show a reduction in size, reduction in extent of ribs, reduction in length of the micropylar beak, and retention of sessile to short-stalked attachment of the nucellus. The second group would include *P. pusilla, P. hexangulata* and *P. ovale*. The latter species representing the ultimate in reduction of the ribs and micropylar beak; *P. pusilla* the ultimate in size reduction, and *P. hexangulata* only partial reduction of its ribs and micropylar beak. The attachment of the nucellus for all three species is either sessile or short-stalked.

Figure 30 shows diagrammatically the proposed phylogeny for the genus *Pachytesta*. *P. shorensis* (Sailsbury, 1914) because of its size and features of its integument, noted by Hoskins and Cross (1946b), seems to approximate more closely the phyletic line including the species with large seeds, extended micropylar beaks, etc. *P. olivaeformis*, on the other hand, shows several features which tend to place it closer to the second phyletic line in which reduction has occurred. Scott and Maslen (1907) (cf. fig. 12) show the basal portion of the nucellus to be a broad sessile disk similar to that of *P. hexangulata* and indicated for *P. pusilla* by Oliver (1904) (cf. fig. 2). The sclero-

test- for *P. olivaeformis* is heterogeneous, consisting of an outer layer of radiating, prolongations of the intertwined, tortuous cells of the inner layer, giving the outer layer the palisade-like aspect as seen in *P. hexangulata, P. pusilla* and *P. ovale*. *P. olivaeformis* is a longer seed than *P. ovale* or *P. hexangulata* but this size difference is principally due to long micropylar beak of *P. olivaeformis* which is lacking in *P. ovale* and *P .hexangulata*. Of the three genera of the reduction series, *P. hexangulata* compares most favorably with *P. olivaeformis* as to size and the presence of commissured and secondary ribs. For these reasons *P. hexangulata* is placed in the position closest to *P. olivaeformis* (fig. 30). It lies above *P. olivaeformis* because of the reduction in length of the micropylar beak and in the reduction of extent of commissured ribs and numbers and extent of secondary ribs. The proposed phylogeny of the pachytestas indicates that the two lines, of which it is believed to have consisted, were already partially established in Lower Coal Measure times with increased diversity appearing in later horizons of the Carboniferous.

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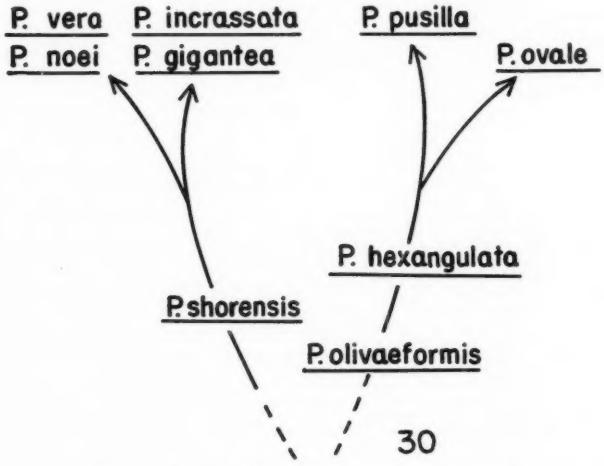

Fig. 30.—Proposed phylogeny for the genus *Pachytesta*.

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Small Spores of the Mystic Coal of Iowa

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Abstract

Thirty-four species of small spores, distributed among twelve genera, are listed from the Mystic coal (Desmoinesian) of southern Iowa. Three new species are described: *Laevigato-sporites globosus, Lycospora rugosa,* and *Vesicaspora wilsonii.* The genus *Vesicaspora* is proposed to include typical bladdered grains of presumed gymnospermic affinity. The assemblage is characterized and compared from four different localities in Iowa and compared to Illinois small spore assemblages of similar age.

Introduction

Studies of the small spore assemblage of the Mystic coal bed of Iowa were begun by the author in 1945 as an undergraduate student of L. R. Wilson at Coe College. In 1946, the author collected the samples which are the basis for this report on the Mystic and allied small spore assemblages. This investigation was essentially completed in 1948. In 1947, the author had the opportunity to examine, in detail, R. M. Kosanke's manuscript on Illinois small spores. An extreme amount of duplication of spore types in our material was evident, and the author decided to withhold publication of the Mystic spores until Kosanke's manuscript was published. Since that time, additional information concerning the Mystic assemblage has been obtained. The author is indebted to L. R. Wilson, L. M. Cline, M. L. Thompson, R. M. Kosanke, and A. T. Cross for aid of various types during the course of the investigations. Type and figured specimens are in the author's collection at the West Virginia Geological Survey, Morgantown, West Virginia.

Stratigraphy and Collections

The Mystic coal bed occurs in the Marmaton group of the Desmoinesian series of the Pennsylvanian system. It is the approximate equivalent of upper Allegheny strata of eastern United States and lower Westphalian D strata of western Europe. The Mystic coal bed in Appanoose County, Iowa, contains two persistent clay partings that separate the bed into three benches. According to Cline (1941, p. 1591) the Mystic coal of this area splits northwestward into two coal beds, presumably at one of the clay partings. In Madison, Dallas, and Guthrie counties, Iowa, the upper bed is termed the Mystic coal and the lower bed, the Marshall coal. The Mystic coal of Appanoose County is correlated with the Herrin (No. 6) coal of Illinois by Weller, Wanless, Cline, and Stookey (1942) and with the Lexington coal of Missouri by Cline (1941). The Mystic coal occurs in the Labette formation which is overlain

by the Myrick Station limestone of the Pawnee formation and underlain by the Higginsville limestone of the Fort Scott formation.

Samples of coal were collected from two localities in Appanoose County and two localities in Madison County. Channel samples were taken of the Mystic and Marshall coal beds in Madison County and of the three individual benches of the Mystic coal in Appanoose County. The localities are as follows:

Locality no. 1.—SW¼ sec. 12, T. 75 N., R. 26 W., Madison County, Iowa. Mystic coal 7 inches thick, Marshall coal 10 inches thick.

Locality no. 2.—NE¼ sec. 13, T. 75 N., R. 26 W., Madison County, Iowa. Mystic coal 6½ inches thick, Marshall coal 12 inches thick.

Locality no. 3.—NE¼ sec. 19, T. 69 N., R. 18 W., Appanoose County, Iowa. Mystic coal, upper bench 20 inches thick, middle bench 12 inches thick, lower bench 1½ inches thick.

Locality no. 4.—SW¼ sec. 16, T. 67 N., R. 16 W., Appanoose County, Iowa. Mystic coal, upper bench 20 inches thick, middle bench 13 inches thick, lower bench 2½ inches thick.

CLASSIFICATION OF SMALL SPORES

The classification of isolated fossil spores is an extremely difficult problem which has not been solved to the complete satisfaction of all concerned with their study. The generic groups as reviewed and delineated by Schopf, Wilson, and Bentall (1944) appear to be the best available at this time. Thirty of the thirty-four species recognized in the Mystic assemblages were either originally assigned to the genera as defined by Schopf, Wilson, and Bentall or were later transferred to these genera. The majority of the Mystic small spores have thus been described and assigned to genera now considered valid. No changes in their classification will be attempted at the present time. A recent paper by Knox (1950) published prior to Kosanke's (1950) publication, however, should be briefly considered. Knox accepted the majority of the emendations of Schopf, Wilson, and Bentall, but proposed four genera to include variously sculptured trilete small spores. Her classification of these types of spores is remarkably similar to the system employed by Ibrahim (1933) which was considerably revised by Schopf, Wilson, and Bentall. Knox's four genera include *Spinoso-sporites, Plani-sporites, Verrucoso-sporites,* and *Microreticulati-sporites.* No genotypes were designated by Knox, but it is evident that three of these genera are antedated in part by those defined by Ibrahim in 1933. Knox assigned to *Spinoso-sporites* the genotype of *Apiculata-sporites* Ibrahim, to *Plani-sporites* the genotypes of *Punctati-sporites* Ibrahim and *Granulati-sporites* Ibrahim, and to *Verrucoso-sporites* the genotype of *Verrucosi-sporites* Ibrahim. *Microreticulati-sporites* was proposed by Knox to include finely reticulate spores of the type usually assigned, accepting the generic definitions of Schopf, Wilson, and Bentall, to either *Punctati-sporites* or *Granulati-sporites.* Knox's genera are based primarily upon ornamentation, while the Schopf, Wilson, and Bentall defined genera are based upon size, shape, and the nature of the trilete suture as well as ornamentation. Admittedly, their classification is difficult, but a sound revision of established spore

genera must consider previously proposed classifiactions and probably should not be attempted unless considerable information is available from fossil fructification studies. The author has, for numerous reasons, refrained from adopting Knox's proposed genera. *Punctati-sporites* and *Granulati-sporites*, rejected entirely by Knox, are retained. For a thorough review of the problems inherent in classifying these and other types of spores, the reader is referred to the publication of Schopf, Wilson, and Bentall (1944).

THE SMALL SPORE ASSEMBLAGES

The macerations of the coal samples provided small spore assemblages of varying quality. The best assemblages, from the standpoints of preservation, variety of species, and number of specimens, were obtained from the samples of the Mystic coal of Appanoose County, while the assemblages of the Mystic and Marshall coals from Madison County were represented by relatively few specimens with poor preservation. The following genera and species have been identified from the Appanoose County Mystic coal macerations. The species followed by an asterisk (*) were recorded by Kosanke (1950) from the Herrin (No. 6) coal of Illinois.

1. *Punctati-sporites fenestratus* Kosanke and Brokaw, in Kosanke, 1950*
2. *P. latigranifer* (Loose) Schopf, Wilson, and Bentall, 1944
3. *P. obliquus* Kosanke, 1950*
4. *P. provectus* Kosanke, 1950
5. *P. quaeritus* Kosanke, 1950*
6. *P. sulcatus* Wilson and Kosanke, 1944
7. *Granulati-sporites granularis* Kosanke, 1950*
8. *G. spinosus* Kosanke, 1950
9. *Laevigato-sporites desmoinesensis* (Wilson and Coe) Schopf, Wilson, and Bentall, 1944*
10. *L. globosus* Schemel, n. sp.
11. *L. medius* Kosanke, 1950*
12. *L. minimus* (Wilson and Coe) Schopf, Wilson, and Bentall, 1944*
13. *L. minutus* (Ibrahim) Schopf, Wilson, and Bentall, 1944*
14. *L. ovalis* Kosanke, 1950
15. *L. punctatus* Kosanke, 1950*
16. *L. robustus* Kosanke, 1950*
17. *Cirratriradites annulatus* Kosanke and Brokaw, *in* Kosanke, 1950
18. *C. annuliformis* Kosanke and Brokaw, *in* Kosanke, 1950*
19. *Endosporites ornatus* Wilson and Coe, 1940*
20. *Triquitrites exiguus* Wilson and Kosanke, 1944
21. *T. insitatus* Kosanke, 1950
22. *T. protensus* Kosanke, 1950*
23. *Calamospora breviradiata* Kosanke, 1950*
24. *C. hartungiana* Schopf, in Schopf, Wilson, and Bentall, 1944*
25. *C. pedata* Kosanke, 1950
26. *C. straminea* Wilson and Kosanke, 1944
27. *Lycospora granulata* Kosanke, 1950
28. *L. rugosa* Schemel, n. sp.
29. *Raistrickia aculeolata* Wilson and Kosanke, 1944*
30. *R. grovensis* Schopf, in Schopf, Wilson, and Bentall, 1944*
31. *Florinites antiquus* Schopf, in Schopf, Wilson, and Bentall, 1944
32. *F.* cf. *similis* Kosanke, 1950
33. *Wilsonia delicata* Kosanke, 1950*
34. *Vesicaspora wilsonii* Schemel, n. gen. and sp.

Additional apparently new and undescribed species have been observed, but in insufficient numbers to warrant their description here. Most of the species listed above have been observed in all macerations studied, but others have been encountered infrequently. The presence or absence of these rarer species appears to depend more upon the quality of the maceration and the

number of slides or individual macerations examined rather than upon limited vertical or horizontal ranges. Those species which are extremely rare are less likely to be observed, even by the examination of many slides, than the more common forms. The following table (table 1) indicates the relative abundance of the more common genera. The similarity of the relative abundance of the genera between the upper bench of the Mystic coal of Appanoose County and the Mystic coal of Madison County, and between the middle bench of the Mystic coal of Appanoose County and the Marshall coal of Madison County appears to be significant. This may indicate that if the Mystic coal does split northwestward from Appanoose to Madison counties, the split occurs at the clay parting between the middle and upper bench. Admittedly, the evidence from spore studies is inconclusive inasmuch as it cannot be definitely proven that the Marshall coal is or is not a separate coal or a split from the Mystic of Appanoose County. Moreover, it is entirely possible that the relative abundance of the genera in the benches of the Mystic coal could change a great deal in the distance between sampled localities.

Of the thirty-one previously described species listed above, twenty were recorded from the Herrin (No. 6) coal, the Illinois equivalent of the Mystic coal, by Kosanke (1950). The remaining eleven species have been recorded by Kosanke from other Illinois coals. He identified six named species from the Herrin coal which the author has not observed from the Mystic coal. The author does not consider the differences here recorded between the Mystic and Herrin assemblages as being particularly significant, inasumch as these differences are mainly between the rarer accessory species. The similarity of these assemblages may not be extremly significant either, because the majority of the species common to both are not particularly restricted in their ranges in coals of Illinois (Kosanke, 1950), Iowa, Missouri, Kansas, or Oklahoma (author's unpublished data). The Mystic assemblage is, however, more similar to the Herrin assemblage than to any other Illinois assemblage as reported by Kosanke. This is rather encouraging, insofar as the possibilities of long distance correlations by means of small spore studies are concerned. Many of the above comments and conclusions are based upon the author's experience with small spore correlation studies at the Missouri Geological Survey. An Information Circular, to be published shortly by the Missouri Geological Survey, will describe the utility of various correlation methods employed and some of the results obtained.

SYSTEMATIC DESCRIPTIONS

Laevigato-sporites globosus Schemel, n. sp.

Fig. 2.

Description.—Spores monolete, bilateral; circular to subcircular in transverse plane; 19 to 30 microns in mean diameter, average approximately 24 microns; surface of spore densely and minutely punctate; exine slightly thickened and opaque; suture extends from one-half to two-thirds the diameter of the spore, lips not prominent.

Remarks.—*Laevigato-sporites,* one of the several omnibus spore genera in the currently accepted classification, includes all small spores with a simple monolete suture and bilateral symmetry. The majority of these spores are believed to be from pteridophytes. The most comparable previously described species is *L. punctatus* Kosanke, 1950. *L. punctatus* is more coarsely and sharply punctate, characteristically larger, and more broadly oval than *L. globosus.* There is difficulty at times distinguishing between specimens of *L. globosus* and *Punctati-sporites obliquus* Kosanke, 1950. They are similar in shape and ornamentation and with only a slight size difference. If the nature of the suture cannot be discerned, it may be problematical to which species, and genus, certain specimens belong.

Occurrence.—Mystic and Marshall coals of Appanoose and Madison counties, Iowa. The author has observed this species in numerous Marmaton and Cherokee coals of southern Iowa, northern and southwestern Missouri, southeastern Kansas, and northeastern Oklahoma. Its long range, throughout more than twenty coal beds, makes it relatively useless as a stratigraphic marker, but it is of sufficient abundance in many of the assemblages to be an important factor in statistical studies.

TABLE 1.—The relative abundance of the more abundant genera of small spores in the Mystic and Marshall assemblages of Madison County, Iowa, and the three benches of the Mystic assemblage of Appanoose County, Iowa.

	Madison County		Appanoose County (Mystic coal)		
	Mystic	Marshall	Upper Bench	Middle Bench	Lower Bench
Punctati-sporites	1-3%	1-3%	1-3%	1-3%	1-3%
Laevigato-sporites	42-46%	66-70%	37-41%	67-71%	74-78%
Calamospora	2-4%	1-3%	3-5%	3-5%	7-12%
Lycospora	48-52%	24-28%	51-55%	21-25%	2-6%
Vesicaspora	rare	rare	rare	rare	6-10%
Others	1-3%	1-4%	1-4%	1-4%	1-3%

Lycospora rugosa Schemel, n. sp.

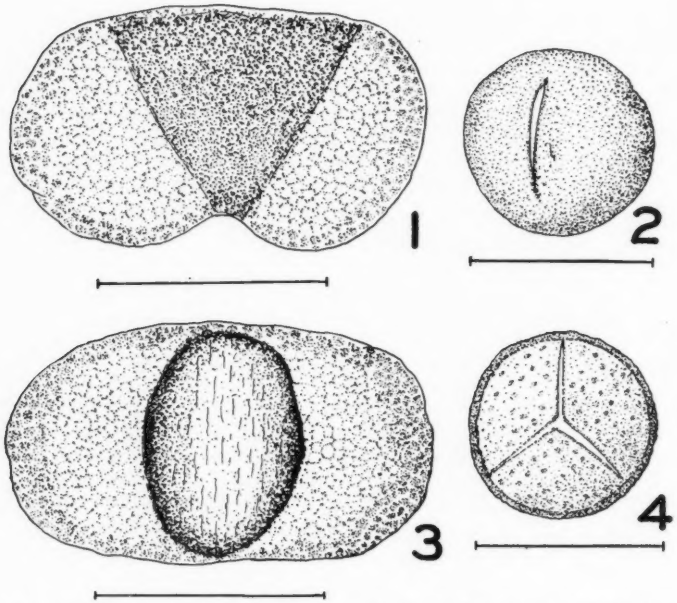
Fig. 4

Description.—Spores trilete, radial; circular in transverse plane; diameter 20 to 26 microns, average diameter 24 microns; surface of spore minutely granulose to ruguse; exine thin and translucent; equatorial ridge 2 to 2.5 microns wide, opaque; trilete rays extend to ridge, lips slightly thickened.

Remarks.—*Lycospora* includes small spores of types frequently encountered in *Lepidostrobus* fructifications. It therefore is considered to indicate the presence of arborescent lepidodendrids. Most of the species of *Lycospora* are similar in their general characteristics, being delineated on size, shape, character of the ridge or "flange," and ornamentation. *L. rugosa* is similar,

in many respects, to *L. granulata* Kosanke, 1950, but the latter averages approximately 10 microns larger and is more coarsely granulose.

Occurrence.—Mystic and Marshall coals of Appanoose and Madison counties, Iowa. As in the case of *Laevigato-sporites globosus*, this species has been observed by the author in numerous Iowa, Missouri, Kansas, and Oklahoma small spore assemblages of Marmaton and Cherokee age.



Figs. 1-4.—1. Lateral view of *Vesicaspora wilsonii*. 2. Proximal view of *Laevigato-sporites globosus*. 3. Proximal view of *Vesicaspora wilsonii*. 4. Proximal view of *Lycospora rugosa*. Bar under each drawing is to scale, representing twenty-five microns.

Genus Vesicaspora Schemel, n. gen.

Genotype.—*Vesicaspora wilsonii* Schemel, n. sp.

Description.—Pollen grains with apparent bilateral symmetry; outline varies greatly with compression, in equatorial view (most common), both bladder and body are ellipsoidal in outline, with the bladder widest at right angles to the long dimension of the body, in transverse view (relatively rare), the bladder is ellipsoidal with a slight sulcus indentation and the body is triangular in outline; total length, inclusive of bladder, of known forms range from 40 to 50 microns, width, from 25 to 35 microns; laterally expanded bladder completely surrounds body, bladder ornamentation laevigate to minutely

granulose externally and finely reticulated internally, body ornamentation obscured.

Remarks.—*Vesicaspora* n. gen. appears to include two bladdered forms described and illustrated by Virkki (1946) from Lower Gondwana strata. These two forms, spore 74 (p. 133, pl. 7, fig. 88) and spore 75 (p. 134, pl. 7, fig. 89 & text fig. 46), were described by Virkki as *Caytonanthus*-like spores to distinguish them from forms described and assigned to *Pityosporites* Seward, 1914. At the present time, bladdered grains of the type illustrated by Virkki (1946) as spore type 76 (p. 139, pl. 7, fig. 104) and by Dulhunty (1946) as spore type 35A (p. 156, fig. 3) and similar bladdered grains observed by the author from various coals of the United States are excluded from this genus. It is possible to recognize morphologic homologies between *Vesicaspora* pollen and various previously described bladdered spore genera, such as *Pityosporites, Endosporites, Alisporites, Parasporites, Florinites, Illinites,* and *Wilsonia.* However, any suggestions of affinities between *Vesicaspora* and these genera would be based upon similarities of structure and therefore quite hazardous. It would also be rather useless to compare spore genera whose natural affinities are not known with any degree of certainty. There is a close similarity between *Vesicaspora* type pollen and those of the Caytoniales as shown by *Caytonanthus* pollen. However, the Iowa species and those described by Virkki are only half as large as the pollen described by Harris (1937) from *Caytonanthus.* There are other differences between these pollen besides the size difference, and thus it cannot be definitely stated that *Vesicaspora* actually records the presence of Caytoniales. It is probable that convergent evolution is responsible for many structural similarities in pollen and spores from widely separated plant groups. Recent work has shown such to be the case, as pollen types previously considered quite specialized have been found in both the Cordaitales and Coniferales. Florin (1950), in discussing pollen grains of Paleozoic and Permian Cordaitales and Coniferales, noted that it is impossible to identify, with accuracy, the genus or family or even the class of many isolated grains. The author considers that any suggestion of affinity, other than gymnospermic, to be an unwarranted assumption at this time.

Vesicaspora wilsonii Schemel, n. sp.

Figs. 1, 3

Description.—Pollen grains with apparent bilateral symmetry; outline varies greatly with compression, in equatorial view (fig. 3), both bladder and body are ellipsoid in outline, with bladder widest at right angles to the long dimension of the body, in transverse view (fig. 1), the bladder is ellipsoidal with a slight sulcus indentation and the body is triangular in outline; total length, inclusive of bladder, ranges from 40 to 50 microns, width, from 30 to 35 microns, in equatorial view, body length ranges from 25 to 34 microns, width, from 13 to 20 microns, in transverse view, body triangular in outline, proximal side varies from 27 to 32 microns in length; bladder ornamentation smooth to minutely granulose externally and reticu-

lated internally, reticulae vary between a fraction of a micron to approximately one and one-half microns wide, bars of reticulae slightly less than one micron thick, ornamentation of bladder conceals ornamentation of body; sulcus area thin and slightly rugose.

Remarks.—The forms similar to *Vesicaspora wilsonii* have been discussed above under the generic description. This species was first observed by the author in Mystic coal assemblages studied under Dr. L. R. Wilson, then at Coe College.

Occurrence.—Mystic and Marshall coals of Appanoose and Madison counties, Iowa. This species has been observed by the author in the Weir-Pittsburg and younger Cherokee and Marmaton coals of Oklahoma, Kansas, Missouri, and Iowa. It is extremely rare and erratic in occurrence in pre-Bevier coals, but becomes relatively common and consistent in the Bevier and younger coals. The occurrence of more than one or two specimens in a thousand specimen count is usually a good indication of a Bevier or younger coal in the areas noted above.

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A Cyclical Occurrence of Cryptozoon undulatum

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Little attention has been devoted to the actual rock record of the cyclical occurrence of reef facies built by calcareous algae. The present paper briefly discusses this subject.

The upper three-fourths of the Warrior limestone formation of Upper Cambrian age (about 1200 feet total thickness) is excellently exposed in three roadcuts along Highway No. 322, Bellefonte Quadrangle, Pennsylvania. Our concern will be with the middle roadcut where a cycle of *Cryptozoon* reef facies is readily traceable. The base of this exposure lies 0.3 miles southeast of the road to Waddle and five miles west of State College.

Table I shows the maximum thickness of individual reef facies, the overlying sediments separating one reef facies from another, and the occurrence of oolitic limestone and edgewise conglomerates in the overlying sediments. Thus, between beds 12.35 and 12.39, one reef facies 8.0 inches thick is separated from the next reef facies (25.0 inches in thickness) by 33.0 inches of sediment, and so on.

TABLE I.—Thickness of Reef Facies and Overlying Sediments*

Bed Number	Maximum Thickness of *Cryptozoon undulatum* reef facies (Inches)	Thickness of Total Overlying Sediments (Inches)	Oolites (O) Edgewise Conglomerates (E)
12.35	8.00	33.00	
12.39	25.00	27.00	E
12.43	9.00	36.00	O**
12.49	2.00	68.00	E
12.59	8.00	39.50	O**E
12.62	1.00	89.00	E
12.69	4.00	115.00	
12.76	8.75	28.75	
12.78	9.50	10.50	O E
12.80	6.50	169.20	O
12.97	9.00		

* Middle roadcut near the top of the Upper Cambrian Warrior Formation.
** Black oolitic limestone facies interfingers reef facies.

It is noteworthy that the reef facies periodically attain a thickness of eight to nine inches. This is true even though they were separated by different time intervals, as shown by the varying thickness of overlying sediments.

The question arises as to whether this recurrence implies anything of significance about the growth habits of *Cryptozoon undulatum* Bassler.

Study of this species by Fenton and Fenton (1937: 437) led to the suggestion that sedimentation probably caused cessation of growth of individual columns of the colony. Thin sections indicated that sediments choked off dome growth in certain columns and that such interruptions were again followed by growth of new domes. Black (1911: 176) reported a similar sequence in calcareous algae of the Andros Islands. There fossil and recent algal heads were smothered by the settling of sediments. The periodic appearance of reef facies in the Warrior formation in itself indicates that turbidity of the water caused by sedimentation halted continued growth of the separate colonies (Tasch, 1951). Nevertheless, this evidence does not explain why growth was interrupted repeatedly at about the same time (that is to say, after an equivalent deposition of calcium carbonate by the algae). The problem may be pointed up by a comparable example.

Gardiner (1898: 427) observed that the thickness of lime in some large nullipores at the rim of Funafuti was between three to four inches, while on the reef itself he never saw a greater thickness than two inches. Since the reef is being built outward from the rim by nullipore deposition, the rim itself may be viewed as equivalent to an algal reef facies. The thickness of three to four inches, therefore, reasonably compares with the figures given in Table I.

Let us hypothecate the following sequence of events. At the rim, nullipore growth will be interrupted periodically by sedimentation after some four inches of lime have been built up. This sequence of growth and sedimentation continues over a considerable period of time. Lithification, followed by uplift, occurs and the entire rim sequence is brought to the surface in the course of geologic time. What we would then have would be a cyclical occurrence of algal facies similar to that of the Warrior formation. The recurrence of the four-inch thickness of reef facies in this instance would offer the same puzzle as does the recurrent eight to nine inch thickness in the Warrior facies.

This recurrent eight to nine inch thickness can be thought of as the norm of calcium carbonate precipitation and hence, of algal growth. The variant thicknesses then become deviations. Accordingly, the deviations may be explained either as immature or overdeveloped growth stages. Fritsch's notation (1935, II: 866) may be relevant here. He observes the occurrence of "immature aggregates" of blue-green forms among living algae and notes that the factors inhibiting full development are as yet unknown.

Reef facies, re-appearing after lapses of time and regardless of the exact thickness of accumulated inter-reef sediment, indicate repetition of those conditions necessary for and promoting algal growth. Studies of both fossil and recent reefs (Glock, 1946) indicate that these conditions are provided by clear, warm water of shallow depth. In terms of light penetration required for photosynthesis and optimum growth conditions, the calcareous algae lived in the euphotic zone. Thus, somewhat in the same way that coal beds recur in cyclothems, reef facies effectively subdivide the upper part of the Warrior

formation. Each subdivision or reef facies signifies prevalence of, or return to, the same prerequisite conditions.

By relating a variety of different kinds of evidence, the ecology of the Upper Cambrian Warrior seas can be reconstructed. Thus, the third column of Table I shows times of occurrence of black, oolitic limestone or edgewise conglomerate facies. Species of the most abundant genus of Warrior trilobites. *Kingstonia*, often occur in association with the oolites. Kingstonid trilobites having smooth, convex cranidia are thought to have lived a burrowing existence. Some oolitic facies interfinger reef facies—a fact which points to deposition in shallow water. Edgewise conglomerates have been interpreted as a mixture of fine sediment and mud crack polygons formed on tidal flats and tossed about by wind or rising tidal waters.

When all of these factors are taken into account, the periodic occurrence of *Cryptozoon undulatum* in upper Warrior time is interpreted as a cycle of alternations from:

1. Times of clear, warm, well-lighted, shallow waters favorable to algal deposition and growth, to

2. Times of increasing turbidity caused by transported sediments from nearby eroding land masses when algal growth was choked off, to

3. Times of excessive shallowing of the water with a scatter of relict pools on a broad, tidal flat.

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New or Noteworthy Plants in the Flora of Alaska

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During the last three summers 1947-49 he spent in Alaska, the writer found a few plants heretofore unreported from this territory, as well as other species the range of which is not well known, and in addition, some botanical variations apparently not yet described. The list of these follows:

Liverworts

Lophozia longidens (Lindb.) Macoun

Central Pacific Coast Distr.: Chugach Mts., Anchorage, *Lepage* 22205, 22206, May 20, 1948.

Widely distributed in North America, but apparently new to the flora of Alaska.

Mesoptychia sahlbergii (Lindb. & Arn.) Evans

Arctic Coast Distr.: Umiat, Colville River, *Lepage* 22600, 22602, Aug. 2, 1948.

This rare liverwort, beside the present locality, is known from the following stations only: Yukon, Hunter Creek (*Williams*); Arctic Archipelago, King Oscar Land: Ellesmere, South Coast, Goose Fiord (*Simmons*), West Coast, Reindeer Cove (*Simmons*), and six other stations in Siberia: Jenesei and Lena Rivers. (See Persson, 1949, and Polunin, 1947.)

Mosses

Brachythemium curtum Lindb.

Central Pacific Coast Distr.: Anchorage, *Lepage* 22418, May 31, 1948.
Apparently the first station to be reported in Alaska.

Bryum calophyllum R. Br.

Alaska Range Distr.: Savage River, Mt. McKinley Park, *Lepage* 25590, Aug. 26, 1949.
New to the flora of Alaska.

Cinclidium latifolium Lindb.

Arctic Coast Distr.: Umiat, Colville River, *Lepage* 22536, 22542, 22543 (in part) July 28, 1948; *Lepage* 22597, Aug. 2, 1948.

This is the third North American station, the other ones being: Melville Peninsula, Vansittart Island (*Freuchen*); Northernmost Quebec, Ivuyivik (*Dutilly*). Also reported from Siberia.

Dicranum sendtneri Limpr.

Central Yukon River Distr.: Richardson Highway, 14 miles south of Fairbanks, *Lepage* 22479, June 16, 1948.

Apparently an addition to the flora of North America.

Didymodon rufus Lor.

Alaska Range Distr.: Nabesna Road, Mile 90, *Lepage* 22163, July 25, 1947.

In North America, previously reported from the following localities: Ellesmere (*Lyall, Simmons*); Melville Peninsula (*Dutilly*); Mingan, north shore of the St. Lawrence River

(*Victorin & Rolland*). This species reaches at Mingan (about 50° 18′ Lat. N.) its most southerly station, hitherto reported.

SPHAGNUM IMBRICATUM Hornsch.

Central Pacific Coast Distr.: Anchorage, *Lepage* 22134, July 8, 1947; *Lepage* 22520, July 10, 1948. — Arctic Coast Distr.: Umiat, Colville River, *Lepage* 22570, July 30, 1948; *Lepage* 22601, Aug. 2, 1948.

Not uncommon in Eastern N. Am., but in western part this species seems restricted to Alaska. Umiat is apparently the northernmost station (69° 25′ Lat. N.) on this continent and perhaps in the world.

VASCULAR PLANTS

EQUISETUM ARVENSE L., var. BOREALE (Bong.) Rupr., f. **atratidens**, f. nov.

Caulis sterilis vix inferne procumbens; a var. boreali differt ramorum vaginis et vaginarum dentibus nigris vel atropurpureis.

Western Pacific Coast Distr.: Miller Point, Kodiak Island, *Lepage* 25005 (*Type* in Herb. Catholic University of America, Wash., D. C.), 25050, June 15 and 20, 1949.

Sterile stem hardly prostrate to the base; this form is distinguished from var. *boreale* by its branches having sheaths and teeth blackish. Like in var. *boreale*, the branches are simple and 3-angled.

ABIES LASIOCARPA (Hook.) Nutt. N. Am. Sylva 3: 38. 1849

Central Pacific Coast Distr.: Chugach Mts., Anchorage, *Dutilly, Lepage & O'Neill* 20537, June 30, 1947.

This station extends further west the range of this species, the western limit hitherto known being Skagway.

FESTUCA VIVIPARA (L.) Smith, Fl. Brit. I: 114. 1800

F. ovina var. *vivipara* L., Sp. Pl. ed. 2, I: 108. 1762.

According to Fernald (1926), "it is not satisfactory to consider *F. vivipara* merely a viviparous state of *F. supina* Schur or of *F. ovina* L., as is done in Europe." Polunin (1940), following Fernald, also treats his collection from Cape Smith, in Northern Quebec, as a species separate from *F. ovina* or its other segregates. A. E. Porsild (1939) published also under *F. vivipara* his collection from Nome, Alaska. However, Hultén (1942) reporting the G. N. Jones collection No. 8976 from Anvil Peak, Nome, "can see no reason to regard it as a separate species . . ." from *F. brachyphylla* Schultes.

In 1948, I collected this viviparous fescue on Anvil Peak, Nome, so that the plants of G. N. Jones, Porsild and our own presumably belong to the same entity. My specimen matches pretty well the description of Fernald (1926), his plate (1935), and fits likewise with the characters of *F. vivipara* pointed out by Scholander (1934).

The reasons quoted by Fernald to distinguish specifically *F. vivipara* from *F. ovina* and *F. supina* are also valid for *F. brachyphylla*, which has aristate lemmas, while they are muticous in *F. vivipara*. After studying many collections of *F. brachyphylla* from Alaska, Northeastern Canada and the Shickshocks Mts., in Gaspé, I can add that in this species the lemmas are glabrous (rarely puberulent on the tip) and indistinctly nerved. On the other hand, in *F. vivipara* (at least for the Alaskan specimen), the lemmas are puberulent all over and distinctly two or three nerved, the median one jutting out from the base to the tip. The glumes are also more strongly nerved than in *F. brachyphylla*.

Viviparous grasses actually recognized as such should not be mistaken for those showing proliferations caused by nematodes, which have transformed the ovary into a long-shaped blackish gall with elongation of both lemma and palea. Such galls have

been noticed on *Arctagrostis latifolia* (R. Br.) Griseb (*W. J. Cody* 1758, Aug. 2, 1948, Coral Harbour, Southhampton Island, N.W.T., fide I. L. Conners), *Hierochloe alpina* (Sw.) R. & S. (*Dutilly, Lepage & O'Neill* 21178, July 13, 1947, Anchorage, Alaska), *Agrostis scabra* Willd. (*Dutilly & Lepage* 16500, Aug. 24, 1946, Attawapiskat River, James Bay, Ont.) whose parasite is the nematode *Anguina agrostis* (Steinbuch) Filipjev. (det. I. L. Conners), *Agrostis tenuis* Sibth. (*Lepage* 3061, July 29, 1941, Rimouski River, Québec). *Anguina agrostis* is also known (fide I. L. Conners) by Dr. W. G. Dore, Ottawa, on *Agrostis alba, A. tenuis* and *Poa pratensis.*

Eames (1909) described a viviparous variety of *Agrostis borealis* Hartm. (*A. borealis* var. *macrantha* Eames; forma *macrantha* (Eames) Fern.). I have on hand a collection of *A. borealis* (*Dutilly & Lepage* 12593, July 7, 1944, Fort George, James Bay, Qué.) which bears the characteristics given in the Eames's original description, but the spikelets of this specimen contain a gall of same appearance as the one described in the aforementioned collections. Such pathogenic proliferations certainly do not deserve taxonomic designation and, consequently, this forma *macrantha* should be discarded.

CAREX ENANDERI Hultén, Fl. Alaska & Yuk. II: 355. 1942

Central Pacific Coast Distr.: Talkeetna Mts., Craigie Creek, *Dutilly, Lepage & O'Neill* 22048, Aug. 8, 1947.

This collection represents an interesting extension of range for this species previously known only from two other remote stations, Skagway and the Aleutian Islands.

CAREX KOKRINENSIS A. E. Porsild, Rhodora 41: 206. 1939

Central Yukon River Distr.: Steese Highway, vicinity of the head of Chatanika River, *Lepage* 23275, June 25, 1948; Steese Highway, 75 miles south of Circle, *Lepage* 23304, June 25, 1948; Steese Highway, along Camp Creek, 49 miles north of Fairbanks, *Lepage* 23273, June 24, 1948; Steese Highway, 103 miles north of Fairbanks, *Lepage* 25346, Aug. 5, 1949.—Bering Strait Distr.: Shungnak, along a creek flowing into the Kobuk River, *Lepage* 25424, Aug. 13, 1949.

This carex had not been recorded from Alaska, except from the type-locality, the Kokrines Mountains.

CAREX HOLOSTOMA Drej., Nat. Tidssk. 3: 449. 1841

Alaska Range Distr.: Nabesna Road, Mile 83, in carex-marsh, *Dutilly, Lepage & O'Neill* 21589, July 25, 1947.—Bering Strait Distr.: Nome, *Lepage* 23850, Aug. 8, 1948; Kotzebue, *Lepage* 25399, Aug. 9, 1949.

Not rare in carex marshes in the mentioned stations. New to the flora of Alaska.

CAREX LANUGINOSA Michx., Fl. Bor. Am. 2: 175. 1803

Central Pacific Coast Distr.: Wasilla, along Alaska Railroad, *Lepage* 23490, July 13, 1948.

New to the flora of Alaska.

CAREX LASIOCARPA Ehrh., var. AMERICANA Fern., Rhodora 44: 304. 1942

Central Pacific Coast Distr.: Anchorage, in bog, *Dutilly, Lepage & O'Neill* 20734, July 8, 1947; *Lepage* 23546, July 19, 1948.

New to the flora of Alaska.

CAREX PODOCARPA R. Br., f. **pallidior,** f. nov.

A specie typica differt utriculis flavioribus et squamis cinnamomeis.

Central Yukon River Distr.: Eagle Summit, *Lepage* 25356, Aug. 6, 1949 (*Type* in Herb. Catholic University of America).

Typical *Carex podocarpa* has its perigynia dark to straw-color with dark shadings and its scales nearly black with lighter midrim. With forma *pallidior*, the perigynia are green to cinnamon and scales cinnamon to light brown.

CAREX PETRICOSA Dewey, Am. Jour. Sci. 29: 246. 1836

Alaska Range Distr.: Mt. McKinley Park, edge of cliff near Toglat River, *Lepage* 25510, Aug. 22, 1949.

This rare sedge, not previously reported to the flora of Alaska, has been collected a few times in Rockies of Alberta and in the Southwestern Mackenzie District (See Porsild, 1943, and Raup, 1947).

CAREX WILLIAMSII Britt. in Britt. & Rydb. Bull. N. Y. Bot. Garden 2: 159. 1901

Arctic Coast Distr.: Umiat, Colville River, *Lepage* 23733, 23763, Aug. 2, 1948.

This seems the northernmost station (69° 25′ Lat. N.) in the world.

ORCHIS ARISTATA Fisch., f. **perbracteata**, f. nov.

Floribus nullis; bracteis numerosis (40-50), valde elongatis.

Western Pacific Coast Distr.: Kodiak Island, Isthmus Point, grassland on low sea-cliff, *Lepage* 25014, June 16, 1949 (*Type* in Herb. Catholic University of America).

The floral parts of this plant have been transformed into many bracts. It was growing among normal plants.

LYCHNIS MACROSPERMA (Porsild) J. P. Anderson, f. **albida**, f. nov.

Caules foliaeque basilares ex toto virides, non purpurascentes; calyx pallidus cum nervis initio viridibus postea flavescentibus, sed non purpurascentibus; petalae albae.

Bering Strait Distr.: Kotzebue, *Lepage* 25413, Aug. 11, 1949 (*Type* in Herb. Catholic University of America).

This plant seems a true albino, with its white petals and the absence of purple pigment ordinarily coloring the basal leaves, stem and calyx.

DELPHINIUM BRACHYCENTRUM Ledeb., f. **pallidum**, f. nov.

Floribus subalbis paululum caeruleo suffusis.

Alaska Range Distr.: Mt. McKinley Park, vicinity of Toglat River, on rock slide, *Lepage* 25516, Aug. 23, 1949 (*Type* in Herb. Catholic University of America).

The flowers of this new plant are creamy-white, while they are blue with typical *D. brachycentrum*.

POTENTILLA ARGUTA Pursh, Fl. Am. Sept. 736. 1814

Alaska Range Distr.: Slana, *Dutilly, Lepage & O'Neill* 21650 (*Coll. B. Travis*), July 26, 1947; Glen Highway, in front of the Matanuska Glacier, *Dutilly, Lepage & O'Neill* 21308, July 16, 1947; Glen Highway, Mile 102, *Lepage* 25282, July 21, 1949.

Hultén (1946) mentions one collection of this plant at Tlechini by Krause, but believes this report needs confirmation. The author has seen, in 1949, some extensive colonies along the Glen Highway, mostly at Mile 102.

TRIFOLIUM AGRARIUM L., Sp. Pl. 772. 1753

Central Pacific Coast Distr.: Goose Bay, *Lepage* 25270, July 16, 1949.

It was surprising to find this European plant naturalized in Alaska; heretofore it had been reported from the eastern States of America only.

ASTRAGALUS ALPINUS L., var. **alaskanus** (Hult.) stat. nov.

A. alpinus subsp. *alaskanus* Hult. Fl. Alaska & Yuk. VII: 1082. 1947.

In this variety, the keel is much shorter than the standard and the wings are narrower

than the keel, but, like in typical *A. alpinus*, calyx and legumes are black-hairy. A form with white pubescence is here described as:

ASTRAGALUS ALPINUS var. ALASKANUS f. **albovestitus**, f. nov.

Leguminibus calycibusque albis pilis vestitis.

Bering Strait Distr.: Kotzebue, *Lepage* 25410, Aug. 11, 1949 (*Type* in Herb. Catholic University of America).

The calyx and legumes are white-hairy, the corolla remaining white with blue shading at the distal end of the petals.

ASTRAGALUS EUCOSMUS Robins., f. **leucocarpus**, f. nov.

Leguminibus (nec tamen calycibus) albis pilis praeditis.

Alaska Range Distr.: Richardson Highway, Mile 150, *Lepage* 23155, June 14, 1948 (*Type* in Herb. Catholic University of America).

This albino with white-hairy legumes, but with normal blue corolla, is different from forma *albinus* described by Fernald (1926) as having white flowers.

In the genus *Astragalus*, several genetic factors seem responsible for the coloration, each of them apparently working independently for the color of calyx, corolla and legumes.

OXYTROPIS NIGRESCENS (Pall.) Fisch., var. **bryophila** (Greene) stat. nov.

O. nigrescens, subsp. *bryophila* (Greene) Hult., Fl. Alaska & Yuk. VII: 1102. 1947. *Aragallus bryophilus* Greene, Proc. Biol. Soc. Wash. 18: 17. 1905

OXYTROPIS NIGRESCENS, var. BRYOPHILA, f. **albida**, f. nov.

Petalis albidis.

Western Pacific Coast Distr.: Kodiak, summit of Old Woman Mountain, *Lepage* 25089 (*Type* in Herb. Catholic University of America), 25089a, June 24, 1949.

In typical var. *bryophila*, the corolla is blue or purple, the purplish calyx is black-hairy, sometimes with few white hairs intermingled; forma *albida* is white-flowered. On our collection 25089, the yellow-greenish calyx is white-hairy with few black hairs. The calyx of No. 25089a is light purple and black-hairy with few white hairs. In like manner with the forms of *Astragalus eucosmus*, the color of petals varies independently from the color of calyx.

LUPINUS NOOTKATENSIS Donn, f. **leucanthus**, f. nov.

Floribus albidis.

Western Pacific Coast Distr.: Kodiak, old field near Buskin lake, *Lepage* 25223, July 5, 1949 (*Type* in Herb. Catholic University of America).

White-flowered specimens have been reported by Hultén (1947), but this form apparently not previously described is rare.

ASTER SIBIRICUS L., f. **albinus**, f. nov.

A specie typica differt floribus ligulatis albidis, phyllariis caulibusque virescentibus, sed non purpureo suffusis.

Central Yukon River Distr.: Richardson Highway, 20 miles south of Fairbanks, *Lepage* 25319, Aug. 2, 1949 (*Type* in Herb. Catholic University of America).

With forma *albinus*, the rays are white, the stem and phyllaries pale green, while on common *A. sibiricus*, the rays are violet, the stem and the phyllaries more or less purple-tinged.

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Notes and Discussion

Pehr Kalm's Description of the Forest Tent Caterpillar, Malacosoma disstria Hubn., which during Certain Years does Great Damage to both Fruit Trees and Forests in North America

In 1750, while Pehr Kalm was in America, he had the opportunity to study a heavy infestation of the Forest tent caterpillar, *Malacosoma disstria Hubn.* His observations were published in *Kongl. Svenska Vetenskaps Academiens Handlingar* 25: 124. 139. 1764, under the title "Beskrifning på et slags Maskar, som somliga år göra stor skada bada på Frukt-träden och Skogarna i Norra America" (Description of a type of worm which during Certain Years does Great Damage to both Fruit trees and Forests in North America).

The wide scope of Kalm's interest in the natural sciences may be judged from the articles which he contributed to the *Handlingar* from 1749 to 1778. There are seventeen papers, and they discuss the economic value of many trees, shrubs and herbs together with their characteristics and medicinal uses, agriculture, climate, animals and insects.

Pehr Kalm

Although Kalm is well known for his extensive travels in North America and his scientific papers on American subjects little biographical material is available in English.[1]

"He was born in Angermanland, Sweden, in March, 1716. His father, Gabrial Kalm, was the pastor of 'Korsnäs Kapell,' and his mother was Catharina Ross. Kalm's early education, said to have been completed with great difficulty, was received at Vaasa. In 1735 he became a student at the University of Åbo, where he planned to study theology. Professor Johan Brovallius, impressed with Kalm's interest in the natural sciences, recommended him to Baron Sten Carl Bjelke, who proved a generous patron. In 1740 Kalm traveled through southern Finland at the Baron's expense. The following year, while traveling in central Sweden, he became acquainted with Linnaeus, who persuaded him to enter the University of Uppsala where he soon won recognition as one of its outstanding students.[2] He became a member of the Swedish Royal Academy in 1745, and in the following year he was appointed lecturer in natural history and economics at the University of Åbo, although he did not have his doctorate at the time. Promotion to a professorship of economics in 1747 made him the leader of students of natural science and economics in Finland.

"Incident to the development of the economics aspect of the natural sciences, Kalm communicated with Linnaeus. Through their combined efforts, the funds necessary for a journey in North America were obtained, contributions being made by the Swedish Royal Academy and the universities of Åbo and Uppsala. While in England on his way to America, Kalm met Peter Collinson, whose 'arboretum' at Pecham included a large collection of American plants in cultivation. Collinson was gardener to the King and had many correspondents in the Colonies. Kalm's letter of introduction to Benjamin Franklin, presented on his arrival at Philadelphia, reads:

To Ben. Franklin, Philadelphia.
London, June 14, 1748.

Friend Franklin:

The bearer, Mr. Kalm, is an ingenious man, and comes over on purpose to improve himself in all rational inquires. He is a Swede per nation; and is, as I am informed, employed by the academy of Upsal to make observations on pts of the world. I recommend him to thy favour and notice. By him I send the first volume of the Voyage to Discover Northwest Passage. I hope the pacquet &c., send under the care of Hunt and Greenleaf is come safe to hand.

I am thy sincere friend,
P. Collinson.[3]

Kalm fully appreciated the helpfulness of this kind of letter; in his journal, under the entry of Sept. 15, 1748, he said:

"Letters of recommendation are both useful and necessary for one who travels in a strange country. Through letters he soon became known, loved and believed. How can one establish confidence with those one has never before seen or heared of? . . . Mr. Benj. Franklin, to whom Pennsylvania is so highly indebted for its development and well being and to whom the scientific world is indebted for many new discoveries in electricity, was the first to introduce me. He gave me all necessary information and showed me many favours.[4]

"Kalm arrived in America on September 4, 1748,[5] and remained until February 18, 1751. In October 1748, he made a short trip to New York. From September until June he traveled in the vicinity of Philadelphia, but spent the greater part of his time at Racoon, a Swedish village in New Jersey. It is no longer in existance but there is a creek with that name in the vicinity. During these months Kalm became acquainted with John Bartram, the most prominent American naturalist of that time, who gave him much information and advice.

"In Canada Kalm was received as the guest of the French Government, the officials having been instructed to help him in every possible way in return for the hospitality of the Swedish king to certain French scientists who had visited Sweden. In 1750 Kalm explored Pennsylvania and penetrated northward to Niagara Falls where he visited Fort Niagara and the Iroquois. On his return to Philadelphia he married Anna Margareta Sjöman, the widow of Johan Sandin.[6]

"Kalm's initial interest on his return to Sweden in May 1751 was the distribution of seeds for experimental cultivation. He also prepared several agricultural articles for the *Proceedings of the Swedish Royal Academy*, in addition to the one here translated. In 1753, he began the publication of his famous journal, *En Resa Til Norra America* (Stockholm, 1753-1761 3v.), which was later translated into Dutch, English, German and in part, into French. Kalm finally returned to Finland, where he spent the rest of his life at the University of Abo as professor of economics. He put the arboretum in order and experimented with the culture of American plants. His *Flora Fennica*, published in 1765, is the product of his mastery of the flora of his adopted country. He died at Abo on November 16, 1779." [7]

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Kongl. Svenska Vetenskaps Academiens Handlingar 25: 124. 1764. Description of a type of Worm which does GREAT DAMAGE TO BOTH FRUIT TREES AND FORESTS IN NORTH AMERICA.

Pehr Kalm

After my arrival in North America in the year 1748, I sought to become acquainted with the various remarkable things to be found there in nature. Among other things, I heard a great deal of talk about a worm which appears in certain years in unbelievable quantities on trees, and then does a great deal of damage to them. The information received from the inhabitants about these worms was briefly as follows: During certain years the worms make their appearance in large quantities, but during the interval between these years usually only a few appear. During the years in which the worms emerge in innumerable quantities, they so completely eat up the leaves, that the forests in midsummer are as naked and leafless as in winter. They subsequently attack nearly all kinds of trees; only a few species are exempt. Usually there is at this time of the year intense heat and drought in the area, therefore the infestation of worms often has the injurious effect that the naked trees can not withstand the intense heat; whereby large tracts of timber die out. The English call these insects "caterpillars," a name which they give to various kinds of worms on trees.

The following year, 1749, I travelled through a good part of America. Although I was very observant, I did not succeed in finding any worms which could with certainty be identified as these; so I lost hope of seeing them. However, the worm period fell in 1750. The worms appeared in Pennsylvania and New Jersey woods in enormous quantities. I then had ample opportunity to observe their habits and determine to what species they belong.

During the latter year, the third of April, according to the new style, I was visiting an old Swede by the name of Johan Bengtsson who lived in the country. He said that he had reason to fear worms on the apple trees the following summer, especially if the weather would be dry. As a reason for his fear, he showed me many twigs of apple trees on which there were small knot-like structures, largely composed of insect eggs. The insect had laid the eggs around the twig, egg to egg. The eggs were round like the smallest tops of pins, and were protected from rain and unfavorable atmospheric conditions by a glue-like substance, resembling gray-brown syrup. This coating, which glistened like syrup, had been washed away here and there leaving the eggs exposed. The eggs were found on pear, quince, peach and cherry trees and even on the Pennsylvania birch and hornbeam. In a word, the eggs are frequently found on trees whose leaves are untouched if better food is available, as well as on those trees whose leaves are greedily eaten by the newly hatched worms.

By the fourteenth of April eggs had hatched everywhere. An unbelievable quantity of worms crawled up and down on webs which they spun and ate up the leaves as soon

as the buds opened. By the first of May, orchards and forests were full of mature worms. Before I go further I will describe the worms.

Length varies with age. When newly hatched, the worms are about a line long. Later they increase in size and at maturity they are usually one inch and three lines long.

Head: The head is blunt, smooth and short, dirty grayish blue in color and covered with fine black dots, beset with short black hair. Above the mouth, there is a small white spot. There are two blackish palpi one on either side of the mouth. At the junction of head and body on either side, there is small dirty yellow spot from which a quantity of dark hair, about three lines long, originates. Hair is also present around the mouth, but these hairs are much shorter.

Body: The body is of a light blue color, with other colors intermingled in the following manner. Along the back there are eleven light egg-shaped spots, so placed that the broad end points forward and the narrow end points back. The narrow end gives rise on either side to a pair of pitch-black streaks. The length of such a spot is scarcely half a line and the width is proportional. The spots are regularly spaced. The lighter part of the spot is pure white, while the outer edges tend to a dirty yellow. From each of the black streaks on either side of the yellow spots, there arise a few (3, 4 or 5) light brown upright hairs, about three lines in length. Several short burnt-orange streaks are found surrounding the light spots. On either side of the light spots, there is a small burnt-orange streak or line with black edges, running the length of the back. The side of the body, light blue in color, is covered with small black specks. On either side, a stripe, yellow in the center and black along the edges, runs the length of the body. Except for these stripes the body, is as previously stated, light gray in color and thickly covered with light gray hairs, two lines in length. The abdomen is a dark gray blue.

Appendages: There are eight pairs of appendages. Of the three foremost appendages, the first pair lies forward, well beyond any of the light dots. The next two pairs are placed directly below the first two dots. There are no appendages below the third and fourth dots. Four pairs of appendages are placed under the middle of the body. At the end of the body, somewhat beyond the last spot, there is a pair of appendages with which the worm pushes as he goes. The three foremost appendages are blackish and sharp at the ends. The other five are dark blue near the body, while the extreme ends are blunt and yellowish. The worms can shoot these appendages out or draw them into the body.

The width is about one and one-half lines long and is approximately the same throughout.

I mentioned previously that orchards and forests by the beginning of May were full of these worms.

The worms spin large webs in the apple trees. The leaves are quickly eaten up unless these webs are destroyed and the worms tramped to death as they fall. A smudge built under the trees causes the worms to drop to the ground but they immediately climb up to the trunk, if not killed. If a worm is disturbed while on a leaf, it immediately drops a short distance and remains attached by a fine thread spun from itself as it falls. The upper end of the thread is attached to the place on which the worm was resting. With this thread the worm returns to its former position. When all the leaves on a tree have been eaten up, the worms move to another tree and repeat the same process. Smudges of various kinds are used in an attempt to drive away the worms. Here and there small ditches, about a half a yard in depth and height, are thrown up; and steep boards are placed on the side toward the orchard, in order to keep the worms from coming in from the forests. Worms, going from the forest to the orchard, fall into the ditches and are unable to help themselves, as their appendages can not fasten to the loose soil on the side of the ditch. In most places the pests work so quickly, that it is a waste of time to attempt to exterminate them, for they so completely take possession that the trees are entirely bare. In some places they are not satisfied with leaves but even eat up the young shoots and branches, which have been formed during the year.

The forests are also full of worms. At first they destroy only the leaves of the medium and small sized trees and leave the large ones undisturbed. Later, when the

worms finish the younger trees, hunger forces them to attack the older trees, on which they also eat up all the leaves from root to top. The forest floor is alive. Practically no spot can be found which is free from crawling worms. When the leaves are eaten the worms are forced to come down in search of food. In walking under the trees, one soon becomes covered with worms. Here and there, enclosed by forest, are small meadows, on which the owners have left a few oaks to shade the grass. These are not exempt. When the worms have eaten up the leaves of the surrounding trees they take over the meadows and their trees. The meadows ar so full of worms that one can not take a step without trampling on some of them. If one sits down to rest, one is soon covered with worms. Yards and fences are full of them. They crawl on everything. Standing water becomes black as ink and bitter as gall, when the excrement of worms feeding on oak leaves falls into it.

Sound, due to the activity of worms, can be heard under the trees. The falling of the worms and their excrement causes a constant cracking and snapping on the dry leaves.

In traveling from one place to another, the worms follow a straight line. The fields in many places are composed of rows of stalks, alternating with furrows. When worms following a ridge reach a stalk, they do not go around to the ridge on the other side but crawl up to the top of the stalk over the end and down the other side to the ridge. The route, traveled from forest or orchard to a new location, is as nearly a straight a line as possible. In the fields the highest ridges are usually followed. If the upper edge of the ridge happens to be so narrow that it is only the width of a worm, they follow it closely, worm after worm.

If worms fall into water because of smoke, they reach land quickly. If worms encounter water while traveling along the ground, they turn about and take another route. They swim by twisting the caudal extremity horizontally from side to side. On reaching land they become attached and are able to help themselves. If dropped some distance out in the water, they remain lying on the surface and are unable to reach land. Worms dropped into rum or spirits distilled from sugar are quite resistant and crawl along the bottom of the flask for some time. Now and then I have preserved small snakes and frogs by the same method.

The worms spend the entire day eating or wandering from one tree or place to another. As soon as night comes, they rest where ever darkness overtakes them. After worms have taken quarters for the night, they remain motionless unless a light is brought close enough to burn them and cause them to fall to the ground. If the morning is clear, the worms start moving as soon as the sun is up. If it is cloudy, they remain quiet for a long time. During rainy weather they remain motionless.

The worms even enter the houses after they have finished the leaves of the trees in the orchards. They not only cover the outer walls of the houses, but force themselves through openings in the thin walls. They came to Salem, New Jersey in such quantities that the inhabitants had difficulty in keeping them out of the houses. Toward morning the worms got in in such quantities that the inhabitants often had difficulty sleeping because of the worms getting into their beds. Milk, liquids and food material had to be carefully covered. These worms were not eaten by animals, and birds were not inclined to destroy them. Turkeys were said to eat them occasionally.

The damage to trees was not uniform in all places. In the vicinity of Philadelphia, they had not missed a single tree. The contrary was true in certain places in New Jersey and in the region of Lancaster. I travelled through large tracts of forests where their courtesy was such that they destroyed all the leaves in one place, but left the adjoining tract untouched, although it contained the same trees as those they had enjoyed. In some places they cut into the deepest woods in the following fashion. A hoard of worms travels into the forest in a line twenty to thirty arms length in breadth, and eats the leaves of all the trees encountered but rarely touches a tree on either side of the path. The movements are both marked and interesting. I traveled through large stands of forests in Pennsylvania and New Jersey, where there was not a sign of these pests. Later during the same summer, when I traveled in New York, Albany and the Land of the Iroquois, I asked if there had been a visitation of worms. The inhabitants answered that

they were not aware of any at that time, but that the trees, even in those regions, were damaged by worms during certain years.

It appeared on careful observation, that the trees which had suffered most were those growing on rich lands. The trees remaining untouched were usually those growing on poor dry land. There were, of course, exceptions.

Now I will list the trees and shrubs on which the worms readily feed: *Pear trees,* Pyrus communis Linn. spec. 479. *Apple trees,* Pyrus Malus Linn. spec. 479. The worms are especially fond of the leaves of this tree. *Quince trees,*[1] Pyrus Cydonia Linn. spec. 480. *Wild brier;*[2] The worms not only ate the leaves of this plant, but they also ate the bark on the young stems and branches. *White oak,* Quercus alba Linn. spec. 996. *Black oak,* Quercus rubra Linn. spec. 996 n.9. (3).[3] They are especially fond of the leaves of this tree. *Spanish oak,* Quercus rubra Linn. spec. 996 n.9.a.[4] *Chestnut oak,* Quercus Prinus Linn. spec. 995. *Sassafras oak,* Quercus nigra Linn. spec. 995. *Willow oak,* Quercus phellos Linn. spec. 994. *Black walnut,* Juglans nigra Linn. spec. 997. *Smooth-bark hickory,* a variation of Juglans alba[5] Linn. spec. 997. *Hornbeam,*[6] Carpinus Betulus Linn. Flor. Suec. 872. *Yellow tree,* Liquidambar Styraciflua Linn. spec. 999. The leaves of this tree were extremely tasty to the worms.

The following is a list of plants whose leaves were never eaten: *Dogwood,* Cornus mas. Linn. spec. 117. *Wild grape vine,* Vitis labrusca and Vitis vulpina Linn. spec. 203. It was a satisfaction to see the leaves of grape vines intact climbing on tall oak trees, whose leaves the worms had completely destroyed. *Land blueberry,* Vaccinium mucronatum.[7] Linn. spec. 350. *Sassafras,* Laurus Sassafras[8] Linn. spec. 371. *Red bud,* Cercis Canadensis Linn. spec. 374. *Spoon wood,* Kalmia latifolia Linn. spec. 391. *Common cherry tree,* Prunus Cerasus Linn. spec. 474. Although the apple and cherry trees stood side by side in the orchards, the leaves of the former were completely eaten up, while those of the latter remained untouched. *Tulip tree,* Liriodendron.[9] Linn. spec. 535. *Locust tree,* Robinia Psuda-Acacia Linn. Spec. 722. *Mulberry tree,* Morus rubra Linn. spec. 986. *Alder,* Betula alnus[10] Linn. Flor. Suec. 861. *Sycamore,* Platanus occidentalis Linn. spec. 999. *Aspen,* Populus heterophylla Linn. spec. 1034. *Red maple,* Acer rubrum Linn. spec. 1055. *Persimmon,* Diospyros virginiana Linn. spec. 1057. *Fish tree,* Nyssa aquatica Linn. pec. 1058.

The leaves of the following trees and shrubs are sometimes eaten by worms for want of better food: *Persica tree,* Amygdalus Persike[11] Linn. spec. 472. The young leaves are occasionally eaten, but the mature leaves are never touched. *Wild cherry,* Prunus virginiana Linn. spec. 473. *Hawthorne,* Crataegus Crus-galli Linn. spec. 476. *Blackberry,* Rubus occidentalis Linn. spec. 493. *Pennsylvaia birch,* Betula lenta Linn. spec. 983. *Shell bark hickory,*[12] a variation of Juglans alba Linn. spec. 997.

Towards the end of May the worms in many places in the woods were rolled up in leaves on the trees. Others on the ground under the trees lay wrapped, either in dry fallen leaves, or in a fine white material which they had spun around themselves. It was remarkable to see how the worm pulled the edges of the stiff thick leaves together, (for example, the leaves of *Kalmia latifolia*) and placed themselves within in a fine white cocoon.

The eleventh of May I placed some of the worms in glass bottles and fed them the leaves which they ordinarily eat, in order to see what type of insect would finally develop. After eating their fill of the food I had provided, they spun their cocoons in the remaining dry leaves and changed into pupae. The twentieth of June small moths or butterflies of the following emerged:

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1 *Cydonia oblonga* Mill. 2 Probably *Smilax rotundifolia* L. 3 *Quercus velutina* Lam. 4 *Quercus falcata* Michx. 5 *Carya alba* (L.) K. Kock.. 6 *Carpinus caroliniana* Walt. is the American Hornbeam, *C. Betulus* L. is the European Hornbeam. 7 *Nemopanthus nucronatus* (L.) Trel. 8 *Sassafras variifolium* (Salisb.) Ktze.

9 *Liriodendron Tulipifera* L. 10 Possibly *Alnus rugosa* (Du Roi) Spreng. 11 *Prunus Persica* (L.) Stokes. 12 *Carya ovata* (Mill.) K. Koch.

Antennae feather-like, brownish gray upward bent. Eyes globular, brownish. Forehead hairy, hairs brown. At the mouth between the hairs of the forehead, two short tentacles originate. The upper wings are of a dirty yellow color, blended with brown. The upper surface of the wing has two brown transverse lines. The lower wings are of the same color as the upper wings but do not have transverse lines on the upper surface. On the lower surface the wings tend to a light yellow color and look as if they were sprinkled with gilt. There is a transverse brown line on the lower surface of each wing. The upper surface of both pairs of wings is thickly covered with short hairs and is rather shiny. The body is covered with shaggy soft hair of a dirty yellow. There are six legs. The femur and tibia are covered with soft dark brown hair. The tarsis is nearly hairless and the hairs present are extremely short. The wings of the resting moth droop. Wings of the upper pair are four and one-half lines in length and three lines in breadth at the base. The antennae are three lines in length.

During the middle of June I found quantities of these moths in the woods. Some time later I noticed that they laid their eggs on the twigs of all sorts of trees in the fashion previously described. It was predicted that the orchards and forests would suffer a similar fate the following year. Whether this was the case or whether special weather conditions proved a hindrance to the worms I can not say, as I left America for Sweden in February 1751. It is maintained that worms do not occur in such quantities for two successive years.

In the collection which I took back to Sweden I included several branches covered with eggs. The eggs hatched the following summer but as I forgot to look after the small newly hatched worms, they died immediately for lack of food. This experience made me realize the possibility of introducing insects to various parts of the world with similar climates, obviously only useful insects should be introduced.

By the beginning of June of 1750 the trees first stripped of their leaves by the worms had already produced new leaves. During the season in which worms strip the trees those attacked have this in common: they do not produce fruit.

From the foregoing discussion the damage done by these small pests is obvious. Entire tracts of forests are often killed, if intense heat and drought follow the infestation. I was shown large tracts of land where young forests had replaced those killed by the pests seventeen years ago. Åke Helm, a Swede of seventy-odd years, and several others informed me that about forty years ago a frightful quantity of worms attacked the trees. The effect on orchards was much the same. Apples, pear, and quince trees received such a shock that they either died immediately or were so weakened that they rarely regained their former vigor or productivity. I do not know the results of this last infestation, as I left America before they were apparent.

From the above description it is clear that these insects are what Linnaeus in *Syst. Nat. edit. 10: T. I. p. 500* calls *Phalaena Bombyx* (*Neustria*) *elinguis; alis reversis flavescentibus, fascia grisea fesquialtera; subtus unica;* and in the *Fauna Svec.* § *824* calls *Phalaena pectimicornis elinguis; alis deflexis pallidis, falcia alarum transversali saturatiore;* or at least an American variety of that species. It is noteworthy, as well as fortunate, that *Phalaena Neustris,* found in Sweden, lays its eggs in the same manner, although the worms go into the ground and destroy only a very few species.—ESTHER LOUISE LARSEN, Route 4, Crown Point, Indiana.

New Plant Records for St. Joseph County, Indiana

During the summer of 1951 specimens of the following plants were collected by Father Peter Hebert of Notre Dame, Indiana. So far as is known, no published records of these species for St. Joseph County, this state, have heretofore been made. Observations on the different species taken from Deam's *Flora of Indiana* and quoted herewith heighten interest in our report. All specimens were taken within a radius of five to six miles from the University of Notre Dame.

Carex Leavenworthii Dewey. "Frequent, except in the lake area." Collected from a

sandy area in a pasture back of St. Mary's, Notre Dame, Ind.

Carex mesochorea Mackenz. "Rare or local." Oakmont and Studebaker Woods.

Carex gravida var. *Lunelliana* (Mackenz.) Herm. "Rare in the westernmost tier of counties." Sandy ridge in pasture, St. Mary's, Notre Dame, Ind.

Carex alopecoidea Tuckerm. "Known in Indiana from a single collection: Deam no. 41282." 3-I swamp, South Bend; bottomlands behind St. Mary's College.

Carex debilis var. *Rudgei* Bailey. "Infrequent near the northern border of Indiana." Chain-O-Lakes.

Carex hirsutella Mackenz. "Rare in the northernmost counties." Fallow field N. of Community Infirmary, Notre Dame, Ind.

Carex hyalinolepis Steud. "Common, except in the northern three tiers of counties." Margin of St. Joseph Lake, N. of laundry, Notre Dame, Ind.

Carex atherodes Spreng. "Rare in northern Indiana." Swamp just north of cattle barns, Notre Dame, Ind.

Carex Frankii Kunth. "Not known from the two northern tiers of counties." East shore of St. Joseph river, near St. Mary's College.

Carex Emmonsii Dewey. "Found sparingly in the northern counties." Chain-O-Lakes.

Carex scabrata Boott. "Reported from Lake County . . .' but no Indiana specimens could be found." Ravine between Notre Dame and St. Mary's College.

Agrostis scabra Willd. "Agrostis hyemalis of recent authors, in part." Roadside at Indian Graveyard, Angela Blvd., Notre Dame, Ind.

Alopecurus pratensis L. "Collected in Tippecanoe and Wells counties." Fallow field at Indiana-Michigan State Line, ¼ mile W. of U.S. 31.

Alopecurus carolinianus Walt. "Infrequent to local." Baker's pond, 1½ mi. E. of Notre Dame stadium.

Bouteloua curtipendula (Michx.) Torr. "Very local in the state and usually restricted to small areas." Eastern bank of St. Joseph's Lake, Notre Dame, Ind.

Scirpus debilis Pursh. "Found in few counties only." Baker's pond, 1½ mi. E. of Notre Dame stadium.

Eleocharis Engelmanni Steud. Reported from Laporte County. Baker's pond, 1½ mi. E. of Notre Dame stadium.

Berteroa incana (L.) DC. Reported from Laporte, Elkhart, and Steuben counties only. Angela Blvd. and Highway 31, roadside, Notre Dame.

Prunus Cerasus L. "Sometimes spontaneous in Indiana." Eddy St. Woods, abundant in this locality, South Bend, Ind.

Prunus Avium L. "Spread from cultivation." Gray. North shore of St. Joseph's Lake, Notre Dame, and Eddy St. Woods, South Bend, Ind.

Cassia fasciculata Michx. "Probably native." Reported from four counties only, all of the southwestern part of the state. Studebaker Woods; road near fence on western side of woods, South Bend, Ind.

Melissa officinalis L. "Sometimes escaped." Rubbish heap N. of St. Mary's College circa ½ m. N. of St. Mary's College.

Artemisia annua L. "Local throughout southern Indiana"; "Reports of it from Lake and Montgomery counties." River bank near 3-I bridge; just N. of bridge, South Bend, Ind.

Lactuca floridana (L.) Gaertn. Reported from Starke County as our nearest station; railroad embankment near 3-I swamp, South Bend, Ind.

Hieracium aurantiacum L. Reported from Elkhart and Steuben counties only. Sandy field N. of Glendale Creek near Michigan-Indiana state line, circa ¼ m. east of U.S. Highway 31.—P. E. HEBERT, C.S.C., University of Notre Dame, Notre Dame, Indiana.

BOOK REVIEW

NATURAL HISTORY OF MARINE ANIMALS. By G. E. MacGinitie and N. MacGinitie. McGraw-Hill Book Co., Inc., New York. 1949. xii + 473 pp., 282 figs., frontispiece. $6.00.

This is a general book dealing primarily with the marine invertebrates of the Pacific Coast of North America. There are contained in the volume many interesting data, written for the edification of the general public. Toward this objective the authors have contributed much, but for the specialist there is left much to be desired.

The first 100 pages are composed of general information on classification, food types, comparison between fauna of land and ocean, ecologic factors, relationships between animals, sense organs, luminescence, habitats, growth rates, burrowing, variation and succession, and geologic record. In the next 301 pages, the various groups of invertebrates are considered in a phylogenetic manner. Here is found the main substance of the book, the animals' general life histories, morphology, habits and habitats, feeding, and interrelationships are summarized. The next eleven pages are devoted to the prochordates, and 36 pages deal with all marine vertebrates. Fishes receive most attention in this short section with a little on mammals and only incidental remarks on birds and other vertebrates. This is followed by a listing of the phyla of animals as conceived by the authors and compared with a more standard listing. There is then a two-page listing of general habitats of phyla and classes.

By no means will the classification set forth in this book be unanimously accepted. Especially is this so as regards the chordates. The phylum Chordata is not recognized, each of the subphyla is elevated to full phyletic rank with no good basis for so doing. There may be a slight trend toward this in present taxonomic thinking, but it should be undertaken with the utmost caution.

It is evident from a comparison of the sections on invertebrates and vertebrates that the authors are not primarily vertebrate zoologists. The latter section is extremely weak and sketchy and detracts considerably from the pleasing account of the former. There is nothing that can be called a bibliography, only a list of eleven general references. For the layman or high school student the book contains good general information on marine invertebrates and many excellent illustrations. It is a readable volume and well arranged, but the price will most likely prevent wide distribution among the general public for whom it was written.—R. L. LIVEZEY, University of Notre Dame, Notre Dame, Indiana.

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